The Papua and New Guinea Agricultural Journal

Vol. 9 October, 1954 No. 2

Department of Agriculture, Stock and Fisheries,
Port Moresby

ALL OVER AUSTRALIA as well as the U.S.A.

AMES

A.B.C.-COUPLED Aluminium Irrigation Systems

are

Increasing crop yields

Improving Pastures

Saving water

Saving labour

Say good-bye forever to inefficient irrigation! There is an Ames, portable, aluminium irrigation system for all methods of controlled irrigation to round out your investment in land and labour. The self-locking A.B.C. Coupler—no hooks, no latches—ensures quick and easy connecting, and every system is designed to make the most of available water.

To assure higher yields next season

INSTALL AN AMES SYSTEM TAILORED TO YOUR NEEDS

ROTO-RAIN Controlled Overhead Sprinkling

PERF-O-RAIN Low-Pressure Overhead Sprinkling

TOW-A-LINE Power-Move Sprinkler System for pastures, row crops or orchards

GATED PIPE Controlled Furrow Watering

AND WATCH YOUR PROFITS GROW

Full details from "The Irrigation Specialists"

DANGAR, GEDYE & MALLOCH LTD.

10-14 Young Street, Circular Quay, Sydney

P.O. Box 509 — Telegrams: "Dangars" Sydney — Phone: BU 5095

NOTICE TO AUTHORS OF PAPERS

All articles submitted for publication in the *Journal* should be typed with double spacing. Carbon copies should not be sent. Authors are requested to avoid the use of abbreviations and not to underline either words or phrases.

References to articles and books should be carefully checked. In a reference the following information should be given : initials of author, surname of author, full title of article, name of journal, volume, full date, number of the first page of article. If a reference is made to an abstract of a paper, the name of the original journal, together with that of the journal in which the abstract has appeared, should be given with full date in each instance.

Authors who are not accustomed to preparing drawings or photographic prints for reproduction are invited to seek the advice of the Editor.

COMMUNICATIONS

All communications should be addressed to the Editor, *The Papua and New Guinea Agricultural Journal*, Department of Agriculture, Stock and Fisheries, Port Moresby.

SUBSCRIPTION RATES

Commencing with Volume 9, No. 1, *The Papua and New Guinea Agricultural Journal* will be the title for the former publication *Papua and New Guinea Agricultural Gazette*. The publication will still follow the form of the pre-war *New Guinea Agricultural Gazette* and will deal with recent advancement in tropical agriculture and act as an extension medium for the dissemination of agricultural information to the Territory planting and farming community.

Members of the public are invited to submit items of tropical and general interest to agriculturalists in the Territory. Articles from interested persons outside the Territory will be appreciated.

The Annual Subscription payable in advance will be 1s. 6d. postage paid for each issue or 6s. per annum for four issues.

COMMONWEALTH OF AUSTRALIA

TERRITORY OF PAPUA AND NEW GUINEA

Minister for Territories :
The Hon. Paul Hasluck, M.P.

Administrator :
Brigadier D. M. Cleland, C.B.E.

Director of Agriculture, Stock and Fisheries :
R. E. P. Dwyer, Esq., B.Sc. Agr., H.D.A., H.D.D.

The

Papua and New Guinea

Agricultural Journal

Vol. 9 October, 1954 No. 2

CONTENTS

FORMER ISSUES OF *GAZETTE*

The following numbers of the *Agricultural Gazette* have been issued :

New Guinea Agricultural Gazette—

Volume 1, Number 1.
Volume 2, Numbers 1, 2 and 3.
Volume 3, Numbers 1 and 2.
Volume 4, Numbers 1, 2, 3 and 4.
Volume 5, Numbers 1, 2 and 3.
Volume 6, Numbers 1, 2 and 3.
Volume 7, Numbers 1, 2, 3 and 4.

The Papua and New Guinea Agricultural Gazette—

Volume 8, Numbers 1, 2, 3 and 4.

The Papua and New Guinea Agricultural Journal—

Volume 9, Number 1.

Copies of all numbers of the *Gazette* to Volume 7, No. 4, are out of print.

The Papua and New Guinea

Agricultural Journal

Vol. 9 October, 1954 No. 2

CACAO AS A CROP FOR THE OWNER-MANAGER IN PAPUA AND NEW GUINEA

F. C. HENDERSON, B.Sc. (Agr.)*

THE world shortage of raw cocoa has greatly intensified interest in its expansion in Papua and New Guinea. This article is for those who intend becoming owner-managers of a cacao property in the Territory. It is based on questions frequently asked of the Department of Agriculture, by intending settlers and planters. Articles of a more technical nature by Specialist Officers will appear in future *Journals.*

Cacao has better long-term market prospects than any other crop suitable for Territory conditions. World production of cocoa has not increased since the War ; however, the world's population has, and in the West, full employment and rising living standards have increased the potential market. The production lag is due to disease in West Africa and to economic and political factors in the various producing areas. Manufacturers believe that, given reasonably priced cocoa, they could place one million tons per year. Since the War, world production has varied between 650,000-740,000 tons. There has been no carryover from season to season for some time, hence, with no back lag, prices respond rapidly to each crop forecast issued from the main producing centres.

Cacao is indigenous to Central America and occurs naturally as a lower deck tree in rain forest regions, growing in clumps in creeks in the jungle and along watercourses. It requires shade throughout its life. As will be stressed throughout this article, adequate shade, properly handled during the early stages of growth, is the crux of successful cacao growing in this Territory.

The crop is grown from sea-level to 2,000 feet, 20° north and south of the Equator, where the annual rainfall is between 55 inches and 200 inches.

In this Territory it does best where the rainfall is between 80 inches and 120 inches well distributed throughout the year. It is grown successfully here where the precipitation is greater than 200 inches, but under these conditions losses from black pod (*Phytophthora*) may be troublesome. In the dry areas of Southern Papua, the long dry South-East season is not favourable. Trees cease growing for six months of the year, and great care is needed to provide wind-breaks and adequate shade without undue competition for the limited soil moisture. The tree thrives best on a deep, well-drained soil, rich in organic matter, where the water table is below three feet. The best proven soils in New Guinea are the deep, well-drained, free-working pumice soils of New Britain and adjacent islands.

Clearing.

If tackled properly, the clearing of virgin bush for cacao is neither as expensive nor as difficult as is commonly believed. With experience, local labourers can be organized

* Chief, Division of Plant Industry, Department of Agriculture, Stock and Fisheries Administration of Papua and New Guinea.

into reasonably efficient clearing gangs. Undergrowth, vines and brush should be cut before felling commences. All trees must be cut down as any bush tree left standing will cause trouble later.

If the timber is fallen near the end of the wet season, it is normally possible to put a running fire through it in three to four months. Sometimes limbs of large trees are lopped after felling to assist the fire. A good initial burn can save much time and labour, but great care should be taken to choose a suitable time. A cutting and stacking line should never consist of fewer than twenty-five labourers. Smaller numbers mean more cutting, as the timber cannot be handled. Clearing gangs should be issued with full axes. New labourers sometimes object to these, but once accustomed to them will not revert to the three-quarter axe commonly used in the Native villages. All timber is cut either by axes or cross-cut saws into lengths suitable for handling and stacking. Attention to stacking may appear time consuming, but in the long run saves money. Logs should be stacked, where possible, against hardwood stumps, or against hardwood logs too large to move. Large stacks pay dividends, especially when afternoon rains may be expected. Each day, before finishing work, all fires should be "pulled", that is arranged so that half burnt-out logs remain in contact with each other and the burning stump. Many hardwood stumps can be burnt out when the stacks are large and the fires are given attention each night. Once alight, large stacks are not doused even by heavy rain.

The degree of stump grubbing necessary in establishing a new area is a common topic of debate. On virgin land a number of root disease fungi occur in the network of roots of jungle trees. Some of these will infect cacao. In theory complete removal of all timber, stumps and roots would eliminate all sources of root diseases and so give a clean plantation. In practice this is not possible. The amount of grubbing done is a matter of economics. Root disease fungi present in the roots of some jungle trees spread to the young cacao by direct contact of cacao roots and infected material left in the soil. Air borne spore infection from above-ground timber is of minor importance if it occurs at all. The modern idea is to use the growing crop (cacao) as an indicator of sources of root disease infection. It is cheaper and more effective to thoroughly grub and clear limited areas around centres of root rot infection when they are located by the growing cacao trees, than to attempt to remove all stumps and roots during initial clearing operations. Hence the bulk of the grubbing is done not before planting an area but during the early stages of the growth of the crop. Labour and effort can then be concentrated where it is needed, i.e. where root disease actually exists. Stumps not infected are left—they do no harm and slowly rot out.

It is frequently asked if mechanical clearing of virgin jungle is cheaper than the use of Native labour. Although there is little experience on which to base an opinion under New Guinea conditions, all the indications are that bulldozers and heavy tractors still cannot compete with Native labour efficiently used.

Lining.

After clearing, every effort should be made to get shade established quickly to protect the soil and keep out weeds and grass. Do not clear too large an area before commencing to line and establish shade. Concentrate labour on an area that can be handled quickly, that is one on which lining, holing and shade establishment can be completed in four to six weeks. The spacing recommended for our conditions is fifteen feet. This distance should always be used in the initial planting. Later experience may show that local conditions permit a closer spacing. Lining may be done on the "square" or on the "triangle". The latter is recommended as it gives thirteen per cent. more trees to the acre, makes more efficient use of the land than "square" planting, and is just as easy to do. To line on the triangle, a lining wire is required. This is made with three iron rings about three inches in diameter (bull rings may be used) and three lengths of non-stretchable wire (piano wire, or light aircraft cable). The wire must be light, as labourers will not keep heavy wire taut or horizontal when working over logs and around stumps. To make a lining wire, choose a flat piece of ground and drive three iron spikes into the ground to form an equilateral triangle with sides fifteen feet long. Drop a ring over each spike; attach both wires to the ring at the apex (A) of

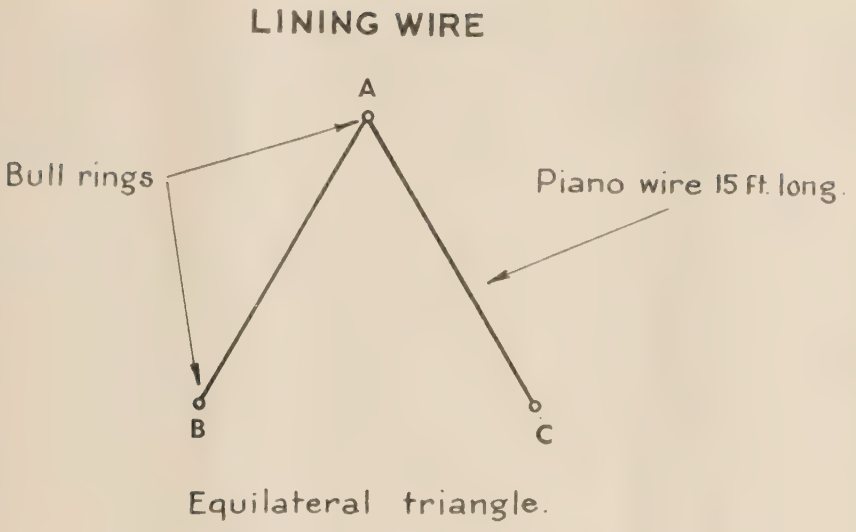


Fig. 1.

the triangle; the others ends of the wire are attached to the rings at B and C respectively. The wire is pulled tight, so that after fastening, the rings will just slip over the iron spikes. These can be left in the ground permanently and used to check the wire from time to time. It is a good practice to instruct labourers to bring the wire in each night after work and drop it over the spikes, then any stretch or change can be immediately detected.

Use of the Wire.

A base line is first marked out by planting straight sticks four feet long at fifteen foot intervals. Lining with the wire commences by holding the rings on the loose ends of the wire against adjacent sticks (A and B in sketch) in the base line and pulling the ring at the apex (A1) taut. This marks the position A1 for the next planting stick. The wire is next held at B and C and point B1 is marked and so on until

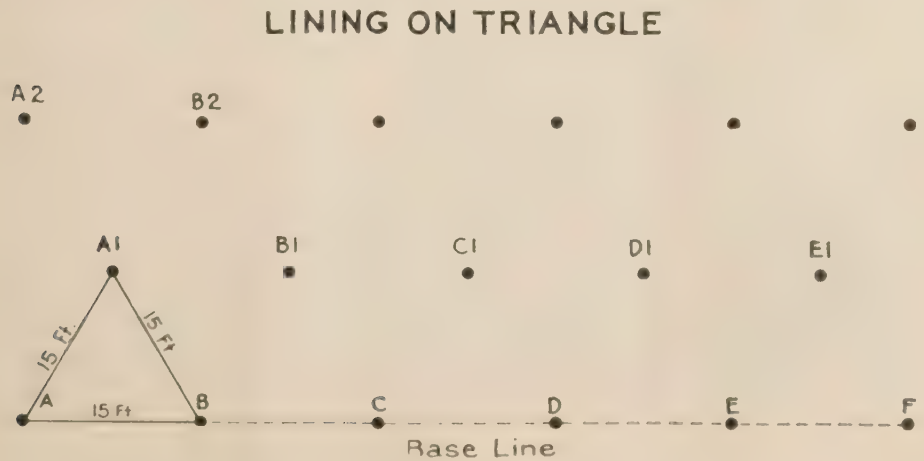


Fig. 2.

the next line of sticks is placed in position. Three labourers are required, one on each ring, and one or two to carry sticks. Labourers can line quickly by this method if taught to watch the following points :—

(*a*) Keep the wire taut.

(*b*) Keep the wire as close to the ground as practicable.

(*c*) Keep both wires horizontal when straddling logs and stumps.

(*d*) See that the lining sticks are vertical before moving on.

(*e*) If using wire above ground level to straddle stumps, ensure that the head of the stick is not pulled out of alignment.

Errors will creep into lining. They are cumulative; hence it is advisable to strike a fresh base line whenever crossing a proposed road.

Holing.

Immediately a block has been lined, holes should be dug and left open to weather. Holes eighteen by eighteen by twenty-four inches are recommended. In the lighter pumice soils, the size of the holes is not as important as on heavy soils. On the latter, and when holing to interplant cacao under mature coconuts, the size of the hole should not be reduced if the young plant is to be given a good start. This also applies when planting at " stake ".

Establishment of Shade.

The provision of ample shade and correct shade manipulation cannot be over-stressed. It is the secret of successful cacao growing in this Territory. Much of the trouble in young plantations, such as unthrifty growth, infestation by pests and diseases, can be put down to faulty shade. If planters forget about their cacao and concentrate on growing a successful shade crop, many of their difficulties will vanish. Correct shade density cuts establishment and maintenance costs.

Shade should be regarded as a protection for the seedling cacao, and as a smother crop to control weed growth. It is false economy to skimp in an attempt to conserve seed when planting shade. A few extra pounds of seed per acre have only to save two or three maintenance cleanings, to pay a dividend. Plant shade quickly after clearing to prevent grass getting into a new area—plant it thickly to keep out grass and weeds. Correct shade density brings cacao into bearing early, whereas faulty shade may delay cropping by twelve months or more. Poorly shaded areas are more liable to attack by leaf and bark eating insects—too densely shaded areas are liable to borer and disease attack.

Cacao requires shade throughout its life but shade is more important in the first three to four years than when the trees are mature. A permanent shade of tree crops may be established, and when sufficiently advanced to give protection, the cacao may be planted. However, to save time, quick-growing shrubs are usually used to give protection for eighteen months to two years while the permanent shade trees are becoming established. It is essential to plant both the temporary and permanent shade at the same time. It is also essential to wait until the temporary shade is giving good cover before putting the cacao in the field. Nothing is gained by getting young cacao seedlings in the field before adequate shade is provided. Without shade they are slow growing and maintenance is costly. Too early planting of cacao costs, not saves, money.

The desirable characteristics sought in a permanent shade tree are :—

(1) Leguminous.

(2) Ease of propagation—cheapness of seed.

(3) Tall growth habit to clear cacao and allow good aeration.

(4) Deep root habit, so as not to compete with cacao for soil nutriment.

(5) Strong wooded, so not liable to wind damage.

(6) Resistance to insect and fungal attack.

(7) Ability to withstand constant pruning.

(8) Ability to provide light, feathery shade.

No tree used in New Guinea fulfils all these requirements. Below are listed trees commonly used for permanent shade in this Territory.

Leucaena glauca approaches the ideal closer than any we have yet tried. It is leguminous, easy to propagate, relatively disease and insect resistant, stands lopping

Fig. 3.
"Crotalaria anagyroides" temporary shade with "Leucaena glauca" permanent shade 6-8 weeks.

Fig. 4.
"Crotalaria anagyroides" temporary shade with "Leucaena glauca" permanent shade. Almost ready for planting cacao.

Fig. 5.
Mature cacao under "Leucaena" shade.

well, is strong and provides a feathery shade. However, it is not tall growing, and it does not give sufficient clearance over the cacao trees. It seeds prolifically and seedlings cause a certain amount of annoyance until the cacao canopy meets and by shading prevents germination.

Erythrina lithosperma is a large, quick-growing tree, readily propagated from cuttings; it is taller than *Leucaena*, but loses its leaves in the dry season when its shade is needed most. It is frequently defoliated by caterpillars; it is subject to borer attack when aged, necessitating its removal after twelve to fifteen years. Due to the size of the tree, its removal entails considerable damage to the surrounding cacao. This is not considered a very suitable shade tree.

Erythrina glauca is a smaller tree than the above species. It does not appear so susceptible to borer attack and has a longer effective life. However, it sheds its leaves in the dry season and is periodically defoliated by caterpillars in some districts in the Territory.

It is regarded more highly as a shade for cacao than *Erythrina lithosperma*.

Albizzia sumatrana is a tall-growing tree, which towers above the cacao and provides a good feathery shade. Its seed is difficult to collect, and the seedlings not easy to establish in the field. It is brittle and liable to wind damage. Not recommended.

Peltophorum inerme is a moderate-sized tree, quick growing and easy to establish from seed. It is rather brittle, but may prove a useful shade in the drier areas of Papua.

Albizzia lubek is a hardwood tree, not as susceptible to wind damage as other Albizzias, provides a feathery shade but is rather slow growing.

Albizzia stipulata is a quick-growing tree with straggly growth habit. It is brittle and is not considered a satisfactory shade tree under coastal conditions.

Coconut. The coconut makes an ideal permanent shade for cacao. Its disadvantage is the long period that has to elapse between establishing the coconut and planting the cacao. It is not wise to interplant a coconut area until the palms are five years old. If planted earlier, temporary shade needed

by the cacao is detrimental to the coconuts. It forces them into a long, leggy mode of growth.

Temporary Shades.

Desirable characteristics sought in a temporary shade plant :—

(1) Quick growth.
(2) Ease of establishment.
(3) Free seeding habit—seed easy to collect.
(4) Ability to last at least eighteen months.
(5) Leguminous.
(6) Resistant to pest and disease.
(7) Ease of eradication if need arises.
(8) Resistance to wind damage.
(9) Ability to grow at least six feet high.

Crotalaria anagyroides. The most commonly used temporary shade in New Guinea ; it is a quick growing shrub, easily propagated from seed. It will give satisfactory temporary shade within three months and will persist for eighteen months under coastal conditions. It is liable to wind damage and is susceptible to " pink " disease (Corticium). The seed is easy to collect.

Tephrosia candida is a shrubby plant, growing six feet to eight feet high. It is more woody than *Crotalaria* and slower growing, but will persist up to three years. It can be used alone but for a quick cover it is better used in a mixture with *Crotalaria.* It supports the *Crotalaria* during its life and carries on after the *Crotalaria* has died out. Its seed is rather difficult to collect and is frequently found to be insect-infested in the pod. Where large trees are used as permanent shade with a spacing of thirty feet and upwards, this is a most useful temporary shade, as it persists sufficiently long to allow the permanent shade to establish a canopy.

Tephrosia vogelii is smaller than *Tephrosia candida,* but is not so tall growing nor as long lived. The seed is not so susceptible to insect attack in the field as *T. candida* ; it has limited use.

Cajanus indicus (Pigeon Pea). This is the quickest growing of all shade species. It gives perfect shade for a short period. It is extremely susceptible to insect and *Corticium* attack. Hence its use is not recommended.

Fig. 6.
Young cacao tree suffering from severe exposure.

Bananas are not recommended for shade under any circumstances. In New Guinea they are a weed, and once established in a cacao area are troublesome for years.

It is recommended that both temporary and permanent shade be planted in the same lines as the cacao at right angles to the base line. With cacao at fifteen feet on the triangle this gives shade lines seven and a-half feet apart (see figure).

A number of shade combinations and planting methods are recommended. In all, the first step is for the labourers to prepare a seed bed by hoeing a continuous strip twelve to eighteen inches wide straight across the field over the open cacao holes.

Method 1.

Temporary Shade—*Crotalaria anagyroides.*

Permanent Shade—*Leucaena glauca.*

Crotalaria seed is dibbled in the prepared beds in a continuous line three feet to six feet each side of the cacao hole. The

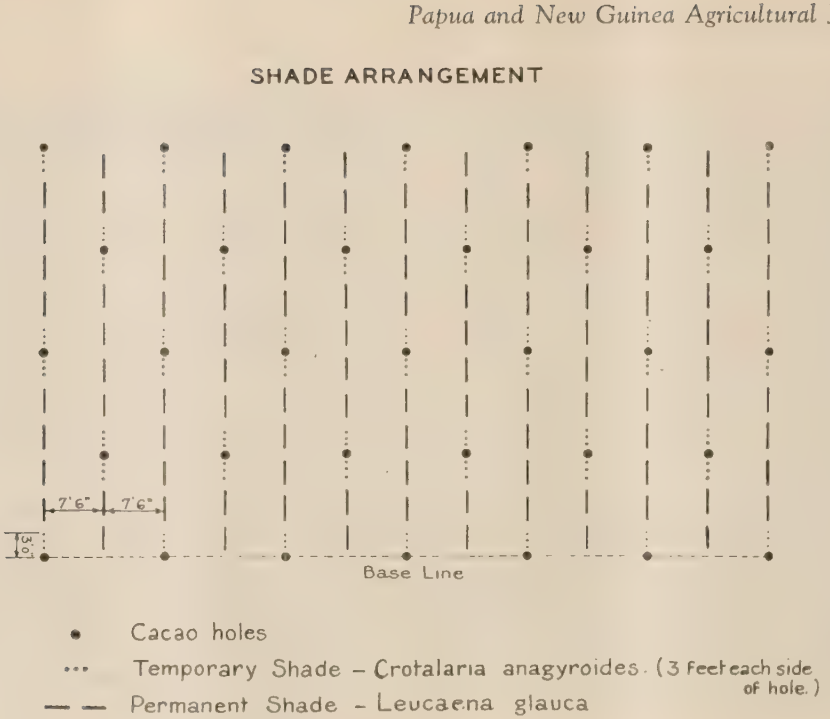


Fig. 7.

Leucaena seed is planted through the remainder of the beds between the holes joining up with the *Crotalaria*.

Method 2.

Temporary Shade—*Crotalaria anagyroides.*

Permanent Shade—*Leucaena glauca.*

Crotalaria is dibbled in a continuous line from cacao hole to cacao hole. Seed of *Leucaena* is planted in with the *Crotalaria* in the mid-section between the holes.

Method 3.

Temporary Shade—*Crotalaria anagyroides.*

Permanent Shade—*Leucaena glauca.* Established from rooted seedlings or cuttings.

This is the same as Method 2 except that the *Leucaena* is established by planting three to five rooted seedlings three feet to four feet long, of finger thickness, instead of seed. Cuttings may also be used but the strike from these is uncertain. *Leucaena* seedlings are hardy and can be pulled out of the ground, topped with a knife, and dropped into holes made with a pointed stick and the ground firmed around them —they will strike easily and readily.

The advantage of Methods 2 and 3 over Method 1 is that a quick coverage is obtained over the whole area and so maintenance is reduced. However, the method is applicable only when ample seed supplies of *Crotalaria* are available.

Method 4.

Temporary Shade—a mixture of *Crotalaria anagyroides* and *Tephrosia candida.*

Permanent Shade—*Leucaena, Albizzia, Erythrina* or *Peltophorum.*

This is the same as Method 1 but 25 per cent. *Tephrosia* seed is added to the *Crotalaria*. The advantages gained are—

(i) the temporary shade lasts longer as the *Tephrosia* carries on after the *Crotalaria* dies out;

(ii) *Tephrosia,* being woody, holds the *Crotalaria* and prevents wind fall.

Where larger species of permanent shade are used they are spaced 30 feet to 45 feet apart, and do not give adequate shade for some time. Hence it is essential, where

these are used, to add *Tephrosia* to the temporary shade mixture to carry on the temporary shade until the permanent canopy is established.

Method 5.

Temporary Shade—*Leucaena glauca.*

Permanent Shade—*Leucaena glauca.*

Leucaena may be used as both a temporary and permanent shade. The seed is dibbled in a continuous line from cacao hole to cacao hole. It grows as a hedge and is continuously reduced until at maturity only one to three plants have been allowed to persist between cacao holes to form the permanent shade.

The planting of cacao is delayed by this method as the *Leucaena* is rarely sufficiently advanced in under six months to give adequate shade to the seedling. The method is used where temporary shade seed is difficult to obtain.

Shade may be established between the cacao lines by any of the above methods or, alternatively, temporary shade may be planted in the lines and permanent shade between the lines of cacao. Neither of the above methods is recommended, as planting both temporary and permanent shade in the same lines as the cacao has a number of advantages :—

(i) Permits early establishment of cacao in the field. The temporary shade being right over the hole gives protection quickly where it is needed.

(ii) Fewer seedlings are damaged by maintenance labourers.

(iii) On the better cacao soils competition between temporary shade and cacao is negligible.

Planting Cacao.

Cacao should not go into the field until the shade is satisfactory. There are two methods of planting :—

(i) At stake ;

(ii) Transplanting from a nursery.

Planting at Stake.

This is recommended wherever possible. The holes left open to weather after clearing are filled with top soil some days before planting and allowed to settle to ground level. Two or three cacao seeds are then planted to a depth of one inch to two inches. If the beans are planted flat side down the incidence of malformed and twisted seedlings is reduced. Before the seedlings reach the five-leaf stage the strongest one is selected and the rest removed.

Fig. 8.
Bench rooting due to bad transplanting.

Planting Out of a Nursery.

The construction of permanent nurseries is not recommended. Temporary ones sited near the new areas reduce transport costs. The sites chosen should be well drained and near water. Making use of standing timber for nursery shade is not favoured. It is better to support a roof of coconut fronds or bush material on wooden posts for shade. As the roof dries it lets in more light and hardens off the seedlings.

Cacao seedlings should never be raised in nursery beds. With New Guinea labour too much damage is done to such seedlings during transplanting. Damage to the taproot in cacao is permanent and distorted roots fail to develop. The seedlings may grow normally in the field but losses by wind fall from three to four year old trees that have been badly planted can be most

serious. Cacao seedlings raised in a nursery should always be grown in pots or baskets. Giant bamboo is available in some districts. This can be made into excellent pots by cutting below the node, removing the bud, and punching a drainage hole through the septum forming the bottom of the pot. The pot is then filled with loamy top-soil or a compost mixture and stood in rows upon loosened soil underneath the shade house. One cacao seed is planted in each pot.

Fig. 9.
Cacao nursery.

If giant bamboo is not available, baskets may be woven out of *Calamus* sp., bamboo, or the fronds of coconuts. The latter is not very satisfactory as the baskets rot in the nursery. Planting tubes may be made from sisalkraft or light gauge galvanized iron. Sisalkraft tubes should be raised above ground level in the nursery as they rot on contact with the ground. Iron tubes are expensive and must be used several times to cut costs.

The day before transfer to the field the seedlings should be watered. Seedlings in palm-leaf baskets can be planted in the field without removing the baskets. Bamboo pots, sisalkraft and iron tubes must always be removed. If left they rot away slowly and restrict root development.

When transplanting, care is needed to see that the tap root is not damaged and the seedling is planted the same depth in the field as it stood in the basket or pot.

Whenever possible planting at stake is recommended. It is cheaper and produces a better-rooted tree. Where giant snails (*Achatina*), rats or ants are troublesome or seed in short supply, it may be necessary to make a nursery.

Selection of Seed.

The establishment of cacao from seed is still the only practical method in the Territory for commercial plantings. The Department of Agriculture, Stock and Fisheries, has developed a simple method of propagating from cuttings, which could be used by planters, and is developing clones suitable for local conditions. However, the high cost of establishing clonal cacao, transport difficulties, the need for much more testing of clones and clonal mixtures, makes the use of cuttings for commercial plantings still some years away. An established planter, wishing to extend his area,

may later be able to use clonal material but it is doubtful if cuttings will ever be used extensively by a new settler establishing his initial living area. The writer believes that the production of clonal seed is possible and practicable and is the next stage in improving planting material for commercial use in the Territory. The Department of Agriculture, Stock and Fisheries is pressing ahead with the production of clonal seed but it will be some years before it will be available for commercial use.

Whenever possible cacao seed should be obtained from the Department of Agriculture, Stock and Fisheries. However, due to transport difficulties it is frequently more convenient to use local seed. Attention should be paid to the following points when selecting local mother-seed trees :—

1. Select on yield, bean size and vigour in that order.
2. Yield can only be assessed by keeping yields over a period of years. Selection for yield on casual examination can be most misleading. Some trees consistently carry a few pods all the year around—others have a definite cropping season. Some trees yield heavily one year but not other years.
3. Observe the position of the tree—is lack of competition giving the tree an unfair advantage which shows in yield and vigour?
4. Examine the internal colour of the beans—avoid extreme types, i.e. those with a very light or very dark "break". Avoid trees giving a wide variation in "break" in individual pods. Too wide a variation in type or "break" is not desirable as it makes satisfactory fermentation difficult.
5. Choose moderately sized plump beans in preference to large flat ones.
6. New Guinea cacao is hybrid material with a high percentage of cross-pollination, hence select widely and do not limit seed collection to a few trees.

Interplanting Mature Coconuts.

The interplanting of mature coconuts with cacao is a most successful form of double cropping. The two crops are widely separated botanically and have few if any common pests and diseases. The coconut provides ideal shade for cacao and the cacao is a most profitable smother crop to reduce maintenance in the coconut area. Some of the oldest interplanted areas in the Territory are now over 50 years old. There is no evidence whatsoever to indicate that coconut yields have been depressed by interplanting, in fact, indications are that the build-up of leaf litter from the cacao more than compensates for the greater drag on mineral nutrients from the soil.

Coconuts are normally spaced at thirty feet in Papua and New Guinea. This is an ideal spacing for interplanting. The cacao is lined at fifteen foot intervals between the coconut lines and in the coconut lines. It is sometimes considered preferable to plant only between the lines to permit freer access and aeration through the area. However, the advantage of greater returns and establishment of a complete smother crop through the area more than outweigh the advantage of better aeration. The incidence of pod rot on areas planted in and between the lines does not appear to differ in any way in areas planted between the lines only.

In interplanting with cacao it is essential to dig large holes to break up the mat of coconut roots and grass and give the young cacao seedling a good start. The holes should be filled with top soil free of roots before planting. Temporary shade is necessary for the cacao in its early stages of development. Where the fronds form a good canopy the construction of temporary shade houses from fallen fronds to supplement shade for three to four months may be sufficient. Where the coconuts are planted at thirty-three feet or where the canopy is not tight it is necessary to grow Crotalaria or some other temporary shade species.

One indication of the need for a living temporary shade is given by the growth of the Crotalaria itself. If it grows reasonably well it is needed—if the shade is such that Crotalaria does not grow, temporary shade houses are adequate. For interplanting with cacao some of the shrubbier Cassia species are probably more suitable than Crotalaria; they are more tolerant of shade.

The advantages of inter-planting are :—

1. Clearing costs are eliminated.
2. Use can be made of established capital buildings and equipment.

3. Land under coconuts for years is free of timber and stumps, and the incidence of root rot is lessened.
4. Maintenance cost on coconuts is reduced by the elimination of grass cutters.
5. The humus content and physical condition of soil beneath the coconuts is improved by the accumulation of leaf litter from the cacao.

The damage done to cacao by falling fronds and nuts is not great. In coconut areas widely spaced or with open areas due to war damage or lightning strike it may be necessary to provide permanent shade additional to the standing coconuts. *Leucanea* can be used for this purpose.

Planting Grass Land.

Kunai (*Imperata arundinacea*) is usually the dominant species on grass land suitable for cacao. Kunai may be suppressed by heavy shade. The difficulty is to get shade established through it. Two methods are recommended :—

(i) The grass is cut and the land ploughed and cultivated. The area is then lined and holed and Crotalaria established quickly and thickly.

(ii) A slower but simpler method is to cut the kunai, line and hole for cacao, then plant three to five well-developed *Leucaena* seedlings between each cacao hole as recommended earlier in this article. If the *Leucaena* seedlings are three feet to five feet high when planted and get away, they will eventually form a canopy and shade out the grass. It may be necessary to cut the kunai two or three times to give the *Leucaena* a good start. It is essential to keep fire out of the area so effective fire breaks are necessary.

Plantation Management.

Efforts spent in cutting traverses across virgin country before beginning operations is well worthwhile. Only from information gained in this way can a planned plantation be established. Bad siting of roads, fermenting house, driers and labour quarters can affect both the cost of development and production, when the property is in bearing. A good layout can reduce transport costs, eliminate much carrying and make the property more attractive to labourers.

Where the topography is suitable, twenty acre to twenty-five acre blocks are a satisfactory size. Smaller blocks waste too much land in roads. Larger ones increase access difficulties. An oblong block twenty chains by ten chains is better than a square one of the same area—it entails less carrying and gives better access for pest control should power spraying become necessary at maturity.

Roads not required immediately can be put under erect shrubby shade or a creeping cover to cut maintenance costs until needed. Fermentaries, driers and labour quarters should be centrally situated and adjacent to water.

Intercropping.

In a young cacao property the practice of growing annual or food crops between the lines of cacao is not recommended. If temporary shade, such as Crotalaria, is used as both a shade and smother crop a complete cover is obtained in three months and weed control is practically eliminated. If the shade stand is reduced to permit the growth of annual or food crops between the cacao lines, both crops suffer, the cacao from lack of shade and the annual crop from too much shade. It is far better to raise annual or food crops on the land before putting down shade for cacao. Intercropping with cacao is not a success. Gains from the annual crop are absorbed by increased maintenance in the area after their removal and by delayed maturity of the cacao. A settler aiming at establishing a cacao property is advised to concentrate on cacao until he has established a living area. The quicker he gets his permanent crop in the ground the sooner will he be financially secure.

Shade Manipulation.

Once a good stand of temporary shade is established, maintenance consists of reducing the cover as the cacao grows. Little effort is required for weed control. As the seedlings grow the temporary shade is progressively cut back from the hole to allow in more light. The general appearance of the plant indicates what is required. With too much shade a seedling develops a " leggy " look, growing tall and spindly ; with too little, growth is checked, leaves become harsh and papery to the feel.

Trimmings from the shade are left on the ground to rot. Slashing of *Crotalaria* and *Tephrosia* is all that is required on the coast as neither of these two covers persists. Where *Leucaena* has been used for both temporary and permanent shade, reduction is more costly. The *Leucaena* must be pulled out or cut out below ground-level. With older *Leucaena* the labourer should scrape away the ground at the butt of the tree and cut down below the surface with a "V" cut.

The stump below the ground will shoot but after two or three slashings will die out. Most of the prejudice against *Leucaena* has arisen from attempts to control areas overgrown with *Leucaena* during the war. Efforts were made to control it by cutting twelve to eighteen inches above ground-level. Such stumps are most persistent but even these and self-sown seedlings die out once the cacao trees begin to touch and form a canopy. By the time a plantation is mature only one or two *Leucaena* trees are left between the cacao. The larger permanent trees are reduced to a permanent stand of one every thirty feet to forty-five feet.

A small shade species like *Leucaena* is an advantage in areas where there is a marked wet and dry season. Under these conditions, heavier shade is required in the dry season than the wet. This means lopping the permanent shade as soon as the wet season begins.

Leucaena is easy to handle, stands lopping well, and no damage is done to the cacao by falling limbs. With larger species lopping is more difficult and damage to cacao is hard to avoid.

There is little place in a well-handled cacao plantation for creeping ground covers. In immature plantations temporary shade will control weeds. In older plantations the cacao itself shades out weeds and by the time the plantation is five or six years old a layer of leaf mould begins building up on the surface.

In any case rampant covers like *Peuraria* or *Centrosema* should never be used. They are troublesome climbers and if left unchecked for any time may smother many young trees.

Dolichos hosei or *Desmodium scorpiurus*, weak or non-climbers are suitable for use with cacao if a creeping ground cover is required. Seed of both is difficult to collect and so they must be established from runners.

Pruning.

With cacao, pruning is a minor charge against plantation maintenance. It is neither difficult nor arduous, but consists mainly of desuckering. It is necessary to understand the habit of growth of cacao to prune correctly. The tree is dimorphous, that is it has two growth forms.

From the seed the plant develops a single straight stem called a "chupon". This generally grows three feet to six feet tall before it ramifies, that is, forms a crown by putting out three to five lateral branches (fanwood). If the tip of a young cacao tree is damaged a lower bud will continue upward growth. A bud on a chupon always produces chupon wood, hence height of ramification is not normally controlled by pruning back or topping.

A tendency to ramify high or low is inherent in the plant, but may be influenced by manipulation of shade density. Heavy shade encourages high ramification, light shade low ramification. Within limits the desirable height of the crown above the ground is a matter of personal opinion. Low ramification makes picking easy; high ramification improves accessibility.

Pruning largely consists of removing sucker shoots from the "chupon" to preserve a single-stemmed tree, or water-shoots from the crown to preserve a single-decked tree. Fanwood may produce a chupon, or a sucker from the main stem may grow straight up like a shoot from the seed and form a second crown three feet to six feet above the first, giving a two-layered tree. This type of tree is difficult to harvest and so should be avoided. The leaves on chupon wood are always arranged in a spiral fashion around the stem at 90° intervals. On fanwood they are spaced opposite at 180°. Labourers can be taught to recognize the two types of growth so that pruning can be done early by rubbing off suckers. If left until later the suckers should be cut off flush with the stem or branch. A sharp knife is more suitable for this than secateurs.

Apart from desuckering, pruning consists of opening up some trees to let in more

light. Little advantage is gained by attempting to shape the crown of a tree. All dead and damaged wood is removed from the tree during pruning operations. Any large wounds are treated with a proprietary wound dressing such as treseal.

Rejuvenation.

Trees damaged by falling fronds or shade can be rejuvenated by stumping back to one foot. A sloping cut is made with a saw, the surface trimmed with a sharp knife, and then treated with a wound dressing or paint. Coal tar is not satisfactory. A chupon comes away from the stump and will form a new tree. If near the ground it will frequently form its own root system, and the old stump rots out. When this happens the chupon after it forms a crown is liable to be blown over before it has time to develop a satisfactory root system. With trees blown down it is better to leave the tree and the chupons will develop along the trunk. One may be selected near the base and the rest removed. When this chupon ramifies and is well developed the fallen trunk can then be cut off above the chupon. Better wound callousing occurs using this method, and the danger of the stump rotting out is reduced.

Pests and Diseases.

New Guinea is very fortunate in being free of the major cacao diseases. Neither Swollen Shoots or Witch's Broom has ever been recorded here. The position with insect pests is not so favourable. A large variety of insects attack cacao in the Territory but most of them are of minor importance and are significant only where the shade is faulty or the crop is growing under unfavourable conditions.

Black Pod Rot (*Phytophthora palmivora*). As in most cacao growing countries of the world, this disease is widely spread throughout the Territory, and causes greater crop losses than any other pest or disease. In Central America the disease causes also chupon wilt and leaf fall, but there is little evidence that it does so in New Guinea. Here it is significant as a pod disease only.

The fungus attacks pods at all stages of development. A brown spot first appears on the pod and progressively extends all over it. With age the infected areas turn black. If infection occurs when the pods are young, they fail to develop, but if older pods are attacked it is possible to harvest some of them before the fungus penetrates to the beans. Infected pods do not fall but persist on the tree. If left hanging the fungus may infect the pod stalk and work back into the fruiting pad. Later fruits developing from infected pads become infected and from there the disease is spread by splashing rain. It is possible to distinguish pad infection from splash infection. With the former, discolouration starts at the stalk end; with splash infection discolouration may begin anywhere on the pod. *Phytophthora* will kill a fruiting pad within three years. In time the fungus may also grow into a branch and cause cankers. A number of these on a branch or twig may eventually cause the death of that part of the tree. Canker damage in New Guinea is generally not serious.

The development and spread of the disease is favoured by humid conditions. Pod rot is always most severe in overshaded plantations in wet weather and in areas of high rainfall.

The disease can be and is controlled in some parts of the world by spraying with Bordeaux mixture, but usually control can be obtained by regular and frequent harvesting if at the same time all diseased, over-ripe or damaged pods are removed from the tree. Black pods left hanging in the trees and infected fruiting pads are the sources of infection from which the disease is carried on from crop to crop. It is dispersed in each crop by splash infection. In West Africa, seven to ten day regular harvesting has reduced the incidence of black pod from sixteen per cent. to four per cent. on experimental areas.

Although figures are not available for this Territory, experience indicates that regular harvesting and removal of infected pods greatly reduce the incidence of this disease. As the disease is spread by rain splashing from infected to clean pods, there is no need to destroy black pods removed from the tree—they can do little harm if left lying in the field.

Regular harvesting with removal of all infected pods is recommended at two to three weekly intervals throughout the year, including the off-season. In young areas attention to regular harvesting even when the crop is of little value prevents pad infection and reduces black pod evidence at maturity.

The lowering of humidity in the cacao field by shade reduction minimizes black pod attack and spraying with Bordeaux mixture is not considered necessary.

Anthracnose *Gloeosporium*—This is a disease of cacao pods. It is common in the Territory but not serious. It differs from black pod in that it can only gain entry to the pod through injury or insect bites. It first appears as small discoloured spots under the skin of the pod. These spots become raised above the surface of the pod and the skin cracks forming pustules, giving the pod a roughened appearance. The spots do not spread laterally to any extent, but the fungus may penetrate inside the pod and destroy the beans. Generally infected pods are still usable. The disease is not of economic importance but in the early stages may be confused with capsid attack. However, capsids cause small sunken water-soaked areas, whereas with this disease the infected areas are raised above the surface of the pod. The fungus may follow capsid damage. The only control necessary is regular harvesting.

Pink Disease—*Corticium salmonicolor*.—This generally is not a serious disease of cacao in the Territory, although it is very common on a wide variety of crops including shade plants such as *Crotalaria, Tephrosia* and pigeon pea.

The disease first appears as a pink encrustation around branches and twigs of trees. The bark splits and the leaves wither and eventually the infected area dies. Occasionally the disease affects young seedlings. Reduction of shade and lowering of the humidity rapidly corrects this. On mature trees the infected area should be cut out and the shade adjusted to lower humidity.

Thread Blight—*Corticium* sp., *Marasmius* sp.—This group of fungi form conspicuous threads which spread over twigs, branches and leaves of the cacao tree. The leaves of the infected area die and frequently hang from the tree suspended by the threads. It is spread by infected material being blown through the plantation. The presence of the disease generally indicates poor soil drainage and humid conditions. Control methods consist of removing infected areas and improvement of soil drainage and reduction of shade. The disease affects a large number of trees other than cacao. It is not serious and indicates generally that the environment in which the cacao is growing is not suitable.

Root Diseases.

As stated earlier these are present in scattered trees in the virgin bush and on clearing may spread to the cacao and shade trees. The incidence of root disease varies considerably from district to district. The South Coast of Papua seems relatively free of root diseases.

On a new plantation root troubles occur in scattered patches and if these are eliminated before the plantation is mature give little trouble. If neglected, areas of infection spread and cause serious loss. A brief description of the more important root diseases is given below.

White Root Disease (*Fomes lignosus*).—The fungus attacks a wide range of trees including cacao and most of the commonly used shade species. An infected tree first appears unthrifty with yellowing and wilted leaves and progressive dieback. Symptoms may develop slowly or the tree may wilt and become defoliated in a few days. When the tap root is infected the tree may blow down before any marked symptoms show above ground-level. On digging out the diseased tree a network of white to brown threads of fungal mycelium can be seen adhering firmly to the infected roots. Although at first superficial, these threads or rhizomorphs subsequently penetrate the roots and advance towards the butt of the tree and eventually kill it. If the dead tree is left the fungus may form fruiting bodies at ground-level. These are large red-brown bracts two to three inches in diameter with concentric dark brown lines. The young bracts have a bright yellow margin and the underside is yellow coloured and pitted. In cross section two layers are visible, one yellowish-white and fleshy, resting on a harder reddish-brown layer composed of closely packed tubes.

Brown Root Disease (*Fomes noxius*).—The above-ground symptoms are similar to those produced by *Fomes lignosus*. Below ground the characteristic feature of the disease is the brown encrustation covering the surface of the diseased roots. This consists of brown mycelium in which soil and even small stones are firmly embedded. The fungus advances towards the collar of the

tree and the encrustation may become visible at ground-level. In the diseased wood, dark lines are visible due to the presence of fungal hyphae. The wood eventually rots. Sometimes the fungus forms fruiting bodies. These are large, hard purplish-brown bracts with yellowish-white growing margins and concentric blackish zones towards the edges.

Wet Rot (*Ganoderma* sp.).—This fungus spreads much more slowly than the two species of *Fomes* mentioned above. It is a root disease of older plantations. Symptoms do not appear until the trees are mature and losses can then be heavy. Diseased roots are covered with red rhizomorphs which are at first superficial. The wood becomes spongy and free water appears when squeezed, hence the name. The fruiting bodies may develop at the base of the tree. They are bract-like knobs, corky or woody, with characteristic light- and dark-brown coloured wavy zones. The growing margin is white and thin.

Collar Rot [*Ustilina deusta* (*zonata*)].—This is common in New Guinea and attacks both cacao and shade trees. Infection is partly by root contact in the soil. The mycelium passes along the roots to the base of the tree and eventually kills it. In such cases the wood shows dark stains due to the aggregation and darkening of the fungus in the wood tissue.

Fructifications are produced around the base of the tree and appear as a more or less formless encrustation. This fungus differs from other root rots mentioned in that it is also a wound parasite infecting trunk and branches through mechanical injuries. Infection is probably also carried by knives, sarifs and hoes of maintenance lines in the plantation, as frequently the fungus is seen on the trunk at ground-level with little sign of diseased roots far from the crown. Care should be taken to see that cacao and shade trees are not injured mechanically during cleaning operations.

Control of Root Disease.

Clean clearing of the original jungle was formerly advised in order to remove all possible sources of root infection. Conscientious adoption of this advice entails great expense in grubbing out stumps and larger roots, and the best that can be expected is a reduction in the degree of infection. It is impossible in practice to remove all timber and roots from a large area and the material left behind may be infected. With rising labour costs clean clearing these days is impossible.

The modern idea is to use the growing tree to locate sources of infection. A cacao root growing through the soil may come in contact with infected material left in the soil from a diseased jungle tree. It develops the disease and the cacao tree dies. This tree is immediately dug out and the roots traced through until the source of infection is located. Labour is then concentrated on the area and all roots, stumps and woody materials are dug up and burnt *in situ* with the diseased cacao tree. Under no circumstances should any material from this infected area be carried through the plantation. An isolation trench may be dug to a depth of two feet around the area to include a number of trees surrounding the infected one. All roots exposed by the trench are examined for disease. If free they are cut and the trench filled in again.

The area enclosed by the trench is dug over and all diseased timber, roots and stumps are removed. The cacao trees are watched closely. The aim with this method of control is to locate the disease centres and eradicate them before the cacao roots form an interlocking network.

If carried out conscientiously, it is effective and labour saving. Effort is concentrated on thoroughly clearing areas where root disease is known to exist. Stumps not infected do no harm and eventually rot out.

In mature cacao stands, root disease control is similar. The trench is dug to include more trees in the isolation area as the cacao roots have formed a network and so more trees are likely to be infected. The trench is filled in and reopened and inspected every twelve to fifteen months until the enclosed area is free of disease. Replanting may be carried out six months after the last sign of disease appears in the enclosed area.

Insect Pests.

Cacao Borers.—Two main types of borers are found in the Territory. Both are indigenous and have moved off native host plants on to cacao.

The principal borer is a brightly coloured iridescent weevil *Pantorhytes plutus*. The adult is about three-quarters of an inch long, cannot fly and is quite long lived. Some have been known to survive for twelve months in an insectary. The adult weevil lives most of its life in the tops of trees, feeding on the bark of young shoots. However, the most serious damage is done by the larvae. The adult moves down from the top of the tree at certain times of the year and lays its eggs in cracks and crevices in the bark of the trunk and main branches. The larvae hatch from the eggs and bore into the sapwood, forming tunnels that normally follow the long axis of the trunk or branch. Sometimes tunnels may girdle a branch, ringbarking it, causing death of the section above the injury. If ringbarking does not occur the tree may suffer considerable mechanical injury without any marked effect. The presence of the borers is indicated by a gummy exudate and frass given out by holes bored to the surface at intervals along the channel. In vigorous, healthy trees this gumming seems effective in checking the larvae as a large number fail to mature, although few show evidence of parasites.

The second main group of borers are Longicorns. The commonest species belong to the genus *Glenea*. The adults are beetles about half an inch long with antennae bent back along the body. The adult is a strong flier and feeds on leaves and the bark of young shoots and chupons. The beetle has a habit of eating along the undersurface of the midrib of young leaves. The larvae of these pests also tunnel through the sapwood and cause damage similar to *Pantorhytes*, but the channels are larger and tend to girdle and ringbark the tree, so damage is more spectacular than with *Pantorhytes*. *Glenea* appears to be favoured by conditions of heavy shade and neglect in plantations. It was very prevalent immediately after the war in old neglected plantations but has become of decreasing importance as these areas have been cleaned up and brought back into normal condition. However, cleaning up appears to have had little effect on *Pantorhytes*.

Method of Control.

The larvae can be dug out and destroyed but it is doubtful if this is worthwhile as the labourers do as much damage as the larvae in this operation. Further, a freely gumming tree seems to check and prevent a large proportion of larvae from reaching maturity. When the adult *Pantorhytes* come down in large numbers from the top of the tree to oviposit, hand collection must give some measure of control.

In new areas before the cacao branches are in contact, *Pantorhytes* borers could possibly be kept out by banding the trees in the immediate vicinity of the standing bush. D.D.T., added to proprietary banding mixtures, has killed borers walking across them nine months after application.

Cacao borers are widespread but their importance as a major pest is localized to certain districts in New Britain.

Capsids.

A number of indigenous capsids have in recent years adapted themselves to cacao. Their natural distribution is unknown but they have been reported from New Britain and a number of localities on the Mainland of New Guinea and Papua. They have caused economic losses as yet on only a few plantations on the Gazelle Peninsula. The recorded species to date are :—

1. *Parabryocoropsis typicus* (Ch. and Car.).
2. *Parabryocoropsis duni* (Ch. and Car.).
3. *Parabryocoropsis cheesmani* (Ch. and Car.).
4. *Pseudodoniella pacifica* (Ch. and Car.).
5. *Helopeltis clavifer* Walk.

These local species attack both pods and shoots but they have been pests of economic importance only on pods. Shoot damage has been insignificant as there appears to be no follow-up of capsid damage by a pathogen like *Colonectria* as occurs in West Africa.

The adult pests are small plant bugs one-quarter inch long, reddish-brown or black in colour.

Some are characterized by having a marked hump when viewed side on. The nymphs are small and active and are commonly found on the sheltered side of the pod. Both the adults and nymphs suck the juice from the pod and in doing so inject a chemical which causes local death of the tissue. This shows up as small brown water-soaked areas on the pod. These later turn black.

When attack is heavy the pod has a speckled appearance. If the cherelles or young pods are attacked they dry out and fail to mature. When a well-advanced pod is attacked it may still mature. Capsid pod damage is frequently followed by secondary pests and fungi.

In West Africa the capsid population is concentrated in certain areas called capsid pockets in a plantation. From these, under favourable climatic conditions, they spread out but retreat when the environment becomes unsuitable again. A similar though not so marked tendency, is evident with New Guinea capsids. Control measures should be concentrated on these pockets when they are static. Although we have not had a great deal of experience with the pest in New Guinea, spraying or dusting appears to be effective and economical. Spraying the whole tree and pods with a 0.2 per cent. D.D.T.-water dispersible spray or dusting with B.H.C. proprietary preparations have given satisfactory control. Spraying gives better and more persistent control than dusting but in areas where water has to be carted long distances through the plantation, dusting, even if more frequent, may prove cheaper and more convenient. Counts by Szent-Ivany indicate that pollination insects rapidly repopulate a sprayed area hence pollination should not be unduly suppressed by treatment, especially if the plantation is sprayed in sections.

Ants.

When planting cacao seed at stake ants are sometimes troublesome. They are attracted by the mucilage surrounding the seed and may destroy the bean before it germinates. Spraying the hole after planting with Chlordane or Dieldrin generally gives satisfactory control.

Snail (*Achatina fulica* Fer.).—In bad snail areas planting at stake is impossible. Snails, if present in numbers, eat off the cacao seedling as it breaks through the ground. They will also destroy older seedlings by chewing around the stem. Normally by the time the seedling has put out five leaves it is through the snail danger.

If snails are not present in too great a number, planting at stake is possible provided the hole is ringed with a mixture of sawdust and metaldehyde in the proportion of a half-ounce to one pound of sawdust. In heavy rains baiting may prove too expensive as the cover bait needs to be replaced frequently. Where snails are very bad a nursery must be established. This can be kept free of snails by constant baiting with sawdust and metaldehyde.

Harvesting.

Only mature pods should be removed from the tree during harvesting operations. The ripeness of the pods is indicated by the colour change, but in the hybrid New Guinea material there is no standard colour change. Experience is the only method of becoming familiar with the colour change pattern and so the recognition of mature pods. The same labour gangs should always be kept on harvesting operations. Ripe pods have a hollow sound when tapped and use can be made of this when training labour to recognize mature pods. Harvesting should be done regularly every two or three weeks and all diseased, wilted or damaged pods should be removed from the tree each time the gang goes around.

Black pods should never be left hanging on the trees (see note in disease section). Pods must be cut from the tree, not pulled. A knife can be used to harvest the lower limbs and trunk, but a cacao hook mounted on a long stick is necessary to cut pods carried high on the trees.

Preparation for Market.

Processing of Crops.—

Cacao beans develop the characteristics of the commercial cocoa only during the fermenting and drying processes. Correct fermenting and drying are essential if a high grade product is to be produced. The best cacao material will not survive faulty preparation for market.

Fermentation and drying should be regarded as parts of one process. Alterations in one necessitate modifications in the other if the best results are to be obtained. The ferment is a natural one brought about by yeasts and other microflora acting on the sugary mucilage surrounding the beans. During the process the following changes occur in the bean :—

1. The temperature is slowly raised until germination is halted and the bean killed.
2. The colour, aroma and flavour characteristics of chocolate are produced.

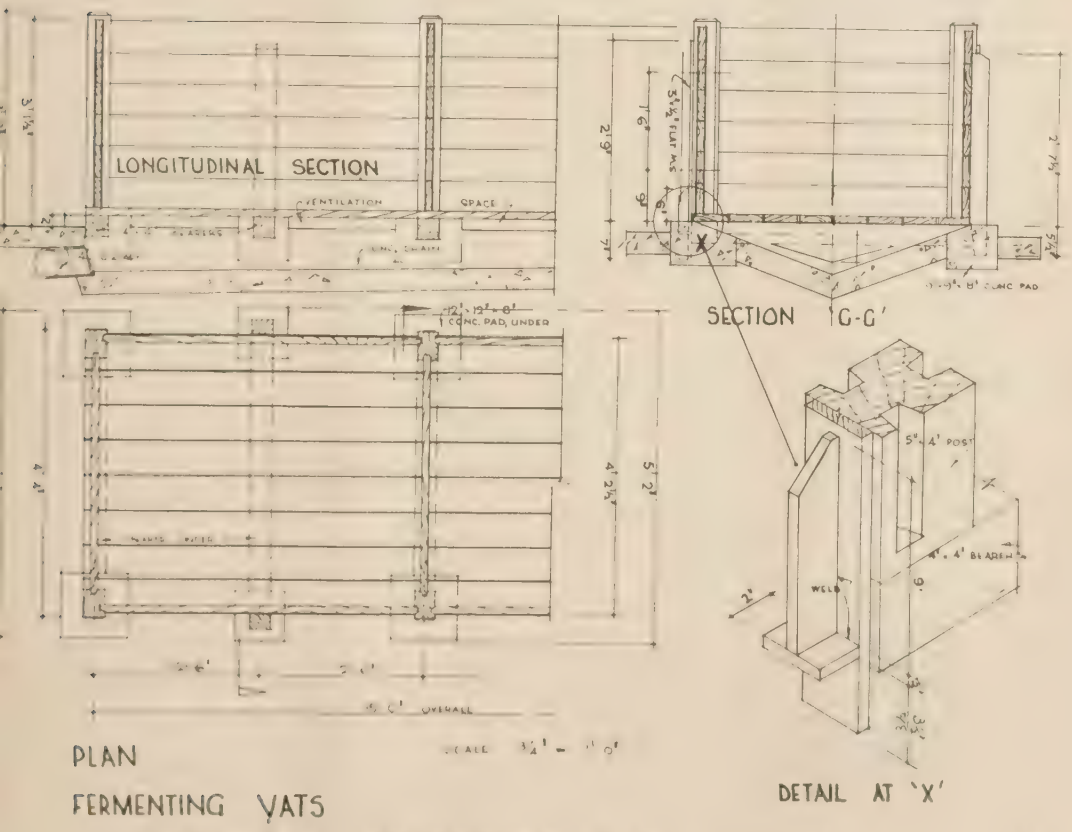
3. The physical characteristics of the bean are altered. The cotyledons open and become loose. The skin toughens and separates from the cotyledons.

The process is carried out by piling the beans in wooden containers for a number of days depending upon the type of bean being treated.

Fermenting Boxes.—

When a new plantation comes into bearing little capital expenditure is needed for processing equipment. A simple wooden box fifteen feet by four feet by three feet divided into three compartments by movable partitions will handle 3,000 pounds of wet beans every second day. The framework of the box needs to be made of seasoned hardwood with four inch by four inch posts resting on five inch by four inch bearers. The sides are made of six inch by one inch planks dowelled or nailed to the inside of the posts. If nails are used then the heads need to be countersunk and the timber burred over them so the wet beans do not come in contact with metal.

Fig. 10.



CACAO PROCESSING PLANT

The partitions are movable and consist of six inch by one inch planks held in position by two inch by one inch slats nailed vertically to the sides of the box. A number of slats may be fixed at two and a-half foot intervals so that the size of each compartment can be changed to give the correct depth of beans with the varying quantities handled.

Drainage holes are bored through the bottom of the box and aeration holes made at intervals along the sides. The box is raised off the ground to let the leachings get away during fermentation. The box is housed in a weatherproof shed which protects it from direct wind but permits good aeration. If the floor of the shed is cement it should be treated with an acid resisting preparation to protect it from the corrosive action of the sweatings.

Individual fermenting boxes four feet by four feet by three feet may be used in batteries of three but the long box with movable partitions is considered cheaper and more flexible to use. Simple boxes as described above will handle quite large crops satisfactorily, but when firmly established a grower usually wishes to construct permanent buildings and fermentary. To indicate the number and size of boxes required, one cubic foot of wet beans weighs fifty pounds.

On sloping land permanent fermenting boxes are frequently arranged in three tiers so that the receiving box can be loaded direct from a truck and during fermenting turned into a lower box by removing the sides. Little advantage is obtained by this system as the beans must still be mixed thoroughly and aerated during turning. When this operation is made too easy, labourers without supervision tend to give too little mixing and aeration suffers. On flat land it is certainly not worth going to the extra expense of building tiered boxes.

A series of horizontal boxes is quite satisfactory and the extra labour required to turn the beans from box to box by hand is not significant in the total cost of preparing the product for market. The fermentary illustrated, designed by the writer, is giving satisfactory results.

It consists of batteries of three fermenting boxes each five feet by four feet by three feet mounted over " V " shaped concrete drains. The boxes are sufficiently high to be charged from the back of a truck. The posts of the boxes fit into holes in the cement, the sides and partitions into slots in the posts so that the whole box and wooden grate over the drains can be taken to pieces, dried in the sun, scraped and thoroughly cleaned. The concrete drain is treated with acid-resisting compounds and can be hosed down to prevent undesirable organisms setting up secondary ferments in the leachings and possibly contaminating the ferment. Cleanliness of the box and fermentary is essential for a regular standard quality product. The sides of the fermentary are enclosed half-way up the walls to protect the box from direct draught and at the loading end by hinged doors. At the discharge end of the box a light trolley line runs out to the sun drier. A rotary drier and bagging space are also housed in the same building.

The Ferment.—

Once the pods have been broken and the beans removed they should be loaded into the fermenting boxes with the least possible delay, care being taken to see that the beans do not get wet during breaking operations and transport to the fermentary. The boxes are filled to a depth of two feet to three feet and covered with an insulating material to reduce the loss of heat during fermentation. Banana leaves are ideal for this purpose. Too great a depth of beans impedes aeration and inhibits fermentation. Too shallow a depth causes excess loss of heat due to radiation. Adjustable partitions in fermenting boxes permit variation in size of the box to give the correct depth for each quantity of beans being handled. The length of fermentation varies with the type of bean and the method of drying to be used later. The paler the break of the bean the shorter the ferment needed, hence too wide a variation of break in a mass of beans means some are over-fermented and some are under-fermented, and a good product cannot be expected.

The slower the drying process the shorter the fermenting period, as fermentation continues for some time on the drying trays. Much more investigation is needed into fermentation and drying methods in the Territory but with our present knowledge growers are advised to commence by using a six-day ferment and

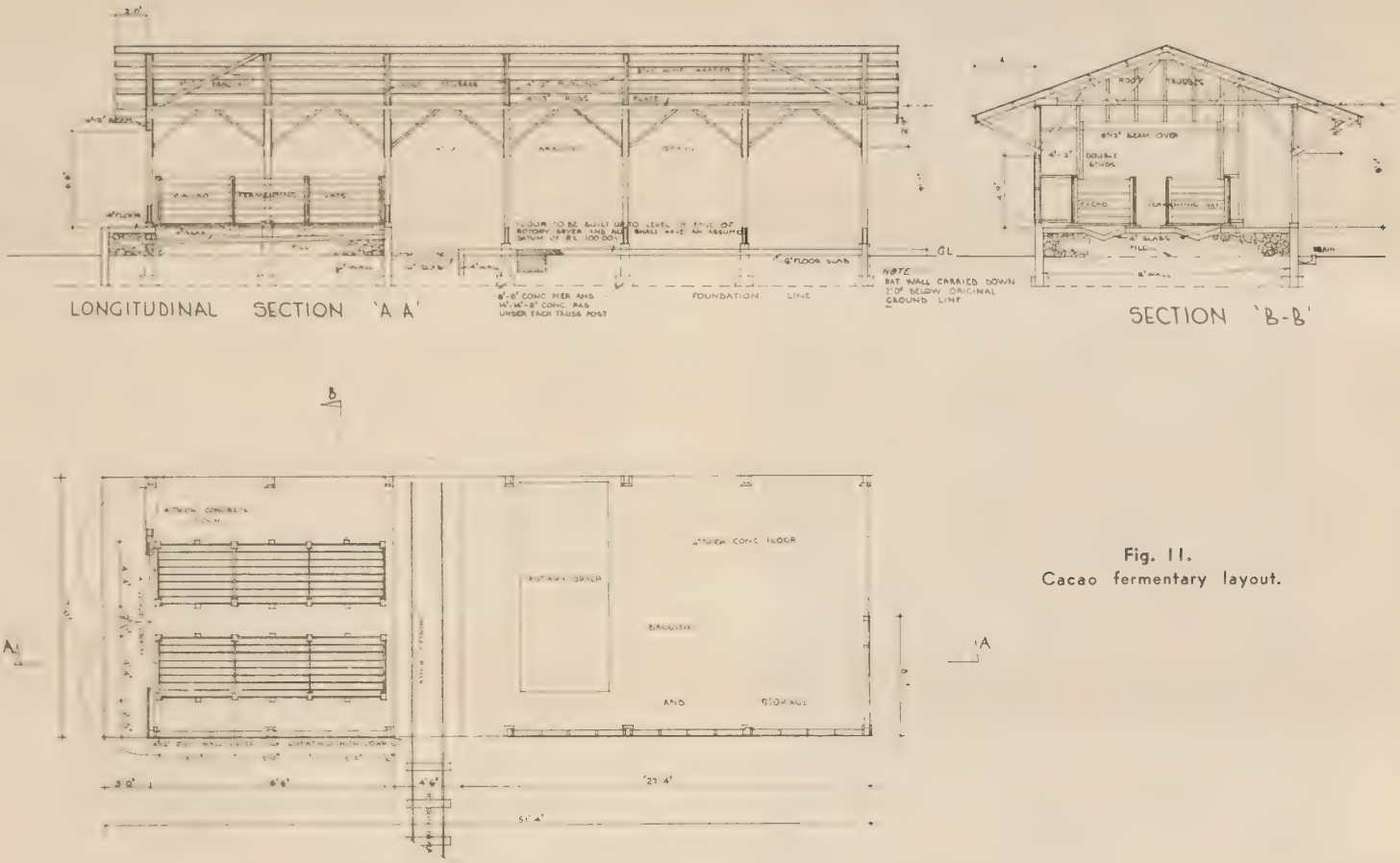


Fig. 11.
Cacao fermentary layout.

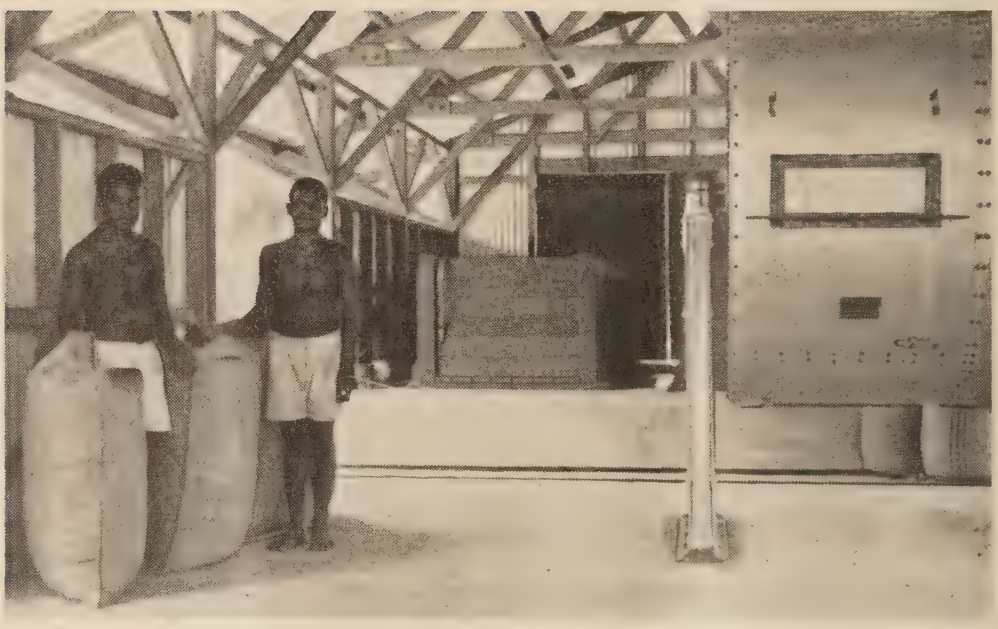


Fig. 12.
Interior view of fermentary.

adjusting this to meet local conditions, if necessary. The ferment is a natural one and so may be affected by minor local differences in temperature, humidity and other factors we know little about. The aim is to raise the temperature of the fermenting beans steadily until it reaches a peak of about 50° Centigrade on the fourth day. Germination processes inside the bean continue for the first period in the boxes and considerable quantities of carbon dioxide are given off. The beans are turned from one box to another to aerate the beans and get rid of the carbon dioxide. Turning every second day is recommended. During the operations the beans are thoroughly mixed to get uniformity and to prevent beans sticking together to form lumps. The operation should be done as quickly as possible to prevent loss of heat but nevertheless mixing should be thorough to ensure good aeration. Occasionally, when handling the off-season crop or when beans mature during dry weather, it is difficult to get a good ferment as the temperature will not rise. Daily turning should then be tried but there appears no justification for more frequent turning. The dryness of the mucilage around the bean may be the cause of some poor ferments occurring under conditions which otherwise appear normal. The fermentation process is completed when the beans show the following characteristics :—

1. They are well rounded and plump.
2. Have developed a faint chocolate aroma.
3. The skin has become tough and is separated from the cotyledons.
4. The cotyledons have developed an open texture and will reopen again after pressure has been applied.
5. A brownish fluid oozes from the beans when cut with a knife.
6. The cotyledons have developed a light or brown chocolate colour.

Under-fermented beans are flat, dry, give a purple or white break and the skin is still attached to the cotyledons. When taken from the fermenting boxes they are frequently lumpy. The external colour of the bean is dark and in very bad ferments almost black with mould on the surface, and an unpleasant sour odour.

Washing of the beans on removal of the fermenting box is not recommended. It improves the external appearance of the beans but there is a loss in weight and the skins become brittle and subject to damage during drying and shipment to market. Manufacturers do not like washed beans.

Driers.—

After fermentation the cocoa may be dried in the sun, in hot-air driers or mechanical rotary hot-air driers. The bulk of the world's cocoa is dried in the sun and a settler in New Guinea may avoid heavy capital expenditure when his crop comes in by using a simply constructed sun drier. As his property reaches maturity he may consider it cheaper to put in a hot-air drier than to continue extending his sun drying facilities. Under New Guinea conditions with ample sun-drying space, large crops can be handled, but with our high and unreliable rainfall a combination of sun and hot-air drying is more convenient and permits the production of a more even line of cocoa throughout the year.

Sun Driers.—

The simplest and cheapest type consists of a long, narrow fixed roof of iron or thatch under which are run bamboo or wooden trays. Trays are moved in and out of the shelter by sliding them on iron or smooth wooden rails supported on posts. The sides of the building are open and the trays from opposite sides are at different levels so that one slides under the other into the shelter.

Sliding-Roof Sun Drier.—

This is a more expensive drier to build but is cheaper to operate as fewer labourers are needed during the drying process. It consists of a wooden platform over which is mounted an iron roof on rails. The roof can be pushed clear of the platform during drying and back over the floor at night or during wet weather. A well constructed drier of the type can be handled by one or two labourers (see plans and illustrations). About 700 square feet of drying space is needed per ton of cocoa.

Hot-Air Driers, Kiln Driers. —

The single-bed hot-air copra kiln can be used for cocoa drying provided :—

1. It is used to dry cocoa only.
2. The flue pipes and joints are sound and there are no leaks of smoke or gases of combustion into the drying chamber.
3. Drying is done slowly.
4. The cocoa is constantly turned on the bed.
5. Beans are not loaded directly out of the fermenting box on to the bed.

Beans should be partly sun dried to get rid of excess moisture before going into the kiln. Hot-air driers with racks of movable trays are not satisfactory as the beans cannot be kept moving. The single bed drier consists of a fixed bed of galvanized copra wire beneath which pass flue pipes carrying hot gases of combustion from a furnace at one or both ends of the building. The furnaces open outside where they are stoked with coconut husks or firewood. The air under the bed is heated by the flue pipes and rises through the cocoa and passes out of ventilators in the roof. Cold air enters the drier through galvanized iron tubes or pipes running from the sides of the building to beneath the flue pipes. The movement of hot air through the cocoa is controlled by regulating the flow of cold air into the drier.

The Hot Floor.—

This is basically a sun and hot-air drier combined. The type of sun drier with a movable roof described earlier is raised above ground-level and enclosed below the bed to give a chamber eight feet to ten feet high. Through this run flue pipes and a furnace similar to a hot-air kiln. The drier may be used for sun drying or as a hot-air drier according to weather conditions.

The floor of the drier must be made of heavier timber than an ordinary sun drier as the heat in time weakens the timber and makes it brittle. The floor must also be made of narrow planks with a gap between each one to allow the hot air to rise through the floor and cocoa. On all types of hot-air driers only high quality galvanized iron should be used and this needs treatment with acid-resisting compounds. The hot-air after passing through drying cocoa is corrosive. Cement-drying barbecues are not recommended. Condensation occurs on them at night, giving mouldy beans and the wet cocoa rapidly pits the surface, making cleaning difficult.

Fig. 13.
Simple sun drier.

Fig. 14.
Sliding-roof sun drier.

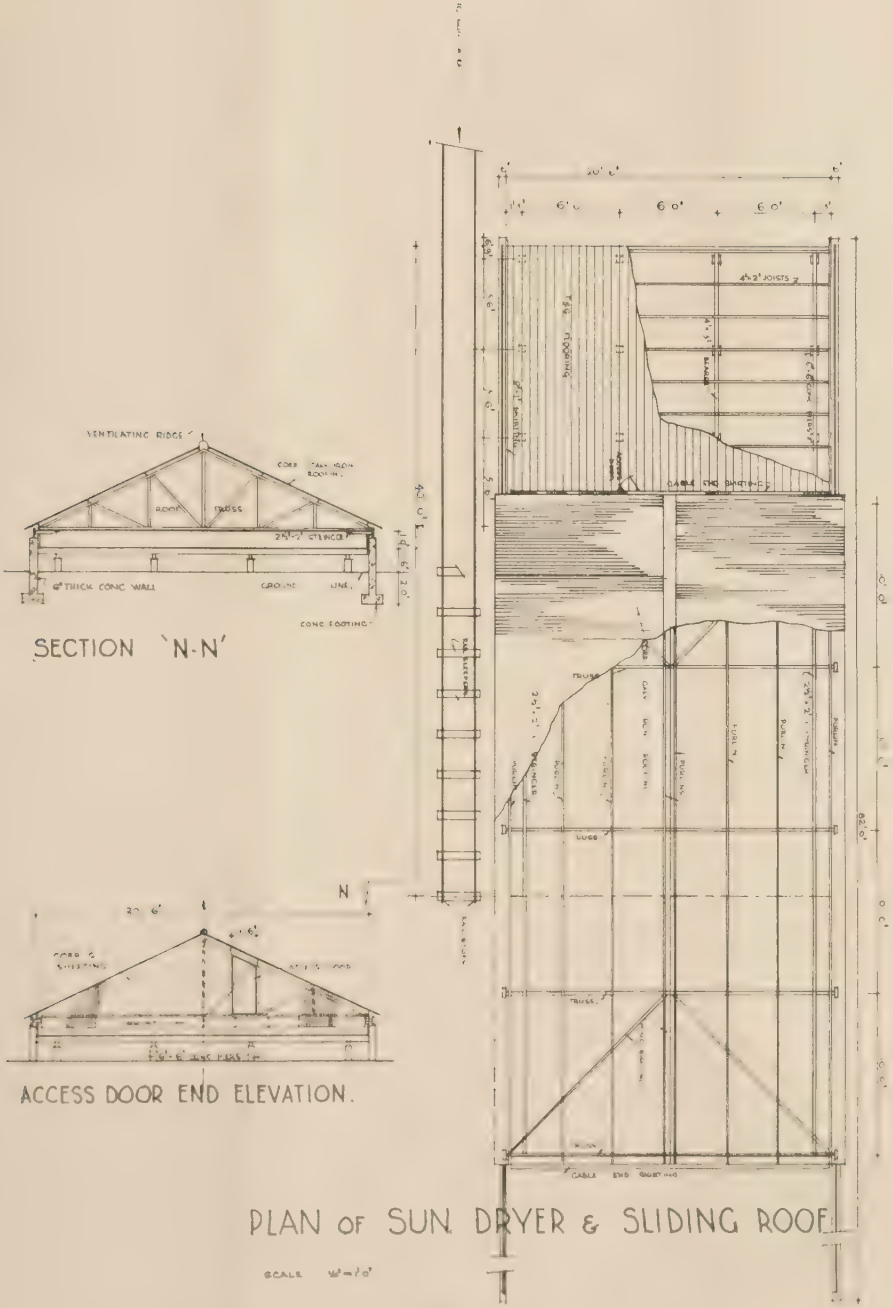

VENTILATING RIDGE
ROOF TRUSS
6" THICK CONC. WALL
GROUND LINE
CONC. FOOTING
SECTION 'N-N'
ACCESS DOOR END ELEVATION.
PLAN OF SUN DRYER & SLIDING ROOF
SCALE

Fig. 15.

Mechanical Driers.—

Rotary cocoa driers are on the market. These consist of a revolving drum through which preheated air is blown. Again they are best used in conjunction with sun drying. After the bulk of the moisture has been removed the rotary drier finishes the beans off very well. It polishes as well as dries and so imparts a good external appearance to the bean.

The Drying Process.—

Wet beans are moved from the fermenting boxes early in the morning and spread thinly on the drying floor to dry off excess moisture quickly. The depth of the beans is increased after a few hours to avoid producing flat and shrivelled beans, as even the sun drying process can be too rapid. In hot, sunny weather the depth of the beans is increased in the middle of the day. The cocoa on the floor is constantly turned to ensure even drying. A labourer with a rake keeps moving the beans into lines or windrows along the length of the drier, exposing in turn part of the floor or drying tray to the sun. This keeps the floor dry. If neglected the planks become sodden and the beans in contact with it develop mould.

Sun drying is normally completed in seven to ten days, according to the weather. Surface mould may develop on the beans during overcast or continued wet weather. It may be removed by "dancing". To do this successfully beans must be at the right stage. If too wet the process flattens the beans. If too dry the skins are broken. "Dancing" is best done on a solid floor. The beans are raked into large heaps containing four hundredweight to five hundredweight. Labourers mark time on the heaps while the beans are constantly shovelled back into the centre. During the operation the heaps are lightly sprinkled with water slightly coloured with Condys crystals. The movement of the beans over each other removes the mould and some of the mucilage and spreads the rest evenly over the bean and imparts a polish. If continued too long the sheen becomes dull again. After dancing the cocoa is spread thinly and drying completed fairly quickly. Dancing will remove external mould and improve the appearance of badly moulded beans.

Hot-Air Drying.—

Too rapid drying in the first two or three days spoils the quality of the cocoa as some of the essential internal changes necessary to develop the characteristics of chocolate continue in the beans during the early stages of drying. Hence some initial sun drying is necessary to produce good cocoa. After this period drying may be completed in hot-air or mechanical driers. In a hot-air kiln the beans are loaded on the bed to a depth of four to six inches and a slow fire maintained in the furnace. Labourers are employed constantly turning the beans to get even drying and on a wire bed to prevent any beans remaining too long in contact with metal. In the drying process the water content of the bean is reduced to six to eight per cent. On completion of the process the beans should be crisp, the skin tough but free of the cotyledons and the nibs crisp and not leathery. Thoroughly dried beans do not mould readily nor are they liable to insect attack.

Marketing.—

Beans should be allowed to cool before bagging. Overseas cocoa is usually marketed in single bags of a standard 140 pound net weight. The bags are slack and easy to handle and stack. The standard weight pack is convenient for recording purposes during shipment and for processing upon arrival at the factory. New Guinea beans are usually double-bagged and packed tightly to no fixed weight. With present high prices double bagging is probably a worthwhile insurance against careless handling during shipment. On the plantation a cocoa store should be weatherproof and well ventilated. Bags of beans should be stacked on timber off the floor and clear of the walls to permit good ventilation. Under no circumstances should cocoa be stored with copra, for it absorbs flavours. Periodically the walls and floors should be thoroughly cleaned and sprayed with D.D.T. to keep down insect pests. Well dried cocoa stored in weatherproof, well-ventilated sheds will keep quite well. Nevertheless it is wise to ship produce out of the tropics as soon as possible. Bags should be numbered and marked clearly with the name of the plantation. This is a trade mark and if known favourably is worth much to the owner.

Disregarding inherent flavour qualities of cocoa the desirable features sought by manufacturers are :—

1. Large plump beans less than 400 to the pound.
2. Unbroken shell crisp and tough, more or less free of the cotyledons.
3. Clean pleasant odour, free of taints such as smoke or fungus.
4. Taste, fatty and nutty, not bitter or astringent.
5. When cut longitudinally the bean should be open grained.
6. Colour brown, dark brown, cinnamon, but not slate or violet coloured.

To indicate trade standards to growers and so assist them to assess their own product, the following minimum requirements for Accra No. 1 grade cocoa are quoted : Grade 1 cocoa which is thoroughly dry, free of foreign matter and contains not more than five per cent. of mouldy, weevily, decayed, flat or germinated beans and not more than five per cent. slaty beans.

New Guinea cocoa inherently has a good flavour. The defects commonly complained about by Australian manufacturers are due to faulty processing and preparation for market. They can be readily corrected by the grower paying more attention to processing and storage on the plantation. The chief defects of New Guinea beans listed by Australian manufacturers are :—

1. *Mould Infection.*—

This may be either internal or external. External mould is not serious but may precede internal mould, gaining entry through any break in the shell.

Internal mould is a most serious defect as it imparts an off-flavour to the finished manufactured article. Consignments with more than five per cent. mouldy beans are usually rejected.

External mould developed (*a*) during drying, can be removed by dancing the beans. This not only improves appearance but lessens the danger of internal mould developing; (*b*) during storage and shipment, can be avoided by thorough drying and storage in weatherproof, well-ventilated sheds.

2. *Insect Infestation.*—

Thorough drying, good storage conditions and marketing in new bags give control.

3. *Malformed Beans.*—

Included in this category are twin or multiple beans, flat, shrivelled, hard, flinty and broken beans. Multiple beans are simply two or more beans which have become stuck together during processing due to insufficient mixing when turning the ferment or insufficient raking in the early stages of drying.

They can be completely eliminated by attention to these two points.

Flat, hard, shrivelled and broken beans can be reduced to negligible proportions by harvesting only ripe pods and fermenting and drying them carefully.

4. *Shell Thickness.*—

New Guinea shell percentage is usually greater than Accra cocoa. This is mainly due to the amount of mucilage around New Guinea beans. Remedy—dancing or use of rotary drier as previously advised.

5. *Improperly Fermented Beans.*—

Being of hybrid stock some variation in bean type is normal in New Guinea cocoa, so careful fermentation and thorough mixing are especially important in this Territory.

6. *Germinated Beans.*—

Always have broken skins and so are subject to internal mould. Proper training and supervision of breaking gangs will eliminate these before they reach the fermenting boxes.

7. *Off Flavours.*—

This refers to flavours absorbed by the cocoa. A hammy flavour is the worst of these as it persists in the manufactured product. It is due to smoke contamination from leaky flue pipes in hot-air driers or to smoke drifting across beans on sun driers. The copra taint is due to storing cocoa and copra in the same store or drying them in the same drier.

8. *Dirt and Foreign Material.*—

Supervision of breaking gangs, regular thorough cleaning of fermenting boxes, driers and packing sheds after each ferment will reduce this to a minimum.

Costs.

The intending cacao planter is most interested in the capital requirements of his venture.

Establishment costs depend on many factors, such as :—

1. Availability of labour.
2. Rate of development.
3. Size of plantation.
4. Standard of living settler is prepared to accept during the development phase.
5. Accessibility and transport costs.
6. Type of country to be developed.

The cost of subsistence and capital installations such as housing, stores, transport and processing equipment varies little for a 50, 150 or 250 acre property. Hence the cost of development per acre decreases rapidly with increasing size of property.

The rate of development is a most important cost factor. It is uneconomic for a settler to supervise fifteen to twenty labourers. A European should be able to handle up to 100 labourers without loss of efficiency. The nearer he approaches this figure the lower the supervision cost per labourer, and the cheaper the cost of development. For example a settler living at the rate of £1,000 per year supervising twenty Natives is spending approximately £4 per labourer per month on supervision. With 60 labourers this drops to £1 6s. 8d. per head. The writer believes it is uneconomic for a settler to commence operations with fewer than 50 labourers.

The optimum cacao area for an owner-manager is considered to be between 250 and 300 acres. A settler should aim at ultimately establishing this area. He will probably not have the initial capital resources to do this immediately but will be forced to establish a smaller area and from the production of this area increase his acreage later to the optimum. However, the larger the area established in the initial planting the cheaper the cost per acre. The planting of 150 acres in the first two years is probably a satisfactory compromise between the minimum and optimum area to aim at in the initial planting.

A budget for 150 acres is given below as an indication of capital requirement.

CAPITALIZATION.

Years	1	2	3	4
	£	£	£	£
Labour .... (Based on 1 labour unit @ 6s.; 100 units clear 1 acre; 25 units plant 1 acre)	4,125	2,475	2,475	2,475
Living Expenses	1,000	1,000	1,000	1,000
House	1,800	—	—	—
Furniture	400	—	—	—
Buildings—				
Labour quarters	750	—	—	—
Stores	100	300	50	—
Drier/Fermentary	—	—	400	—
Tools	400	50	50	50
Transport	1,500	—	—	—
Rent	50	50	50	50
Insurance	100	100	100	100
Transport Expenses ..	200	200	200	200
	£10,425	£4,175	£4,325	£3,875

	£
Total	22,800
Less Production 4th Year	1,500
	21,300
Plus 4½ per cent. Interest 4 years added to Capital	1,917
Total indebtedness end 4th Year	23,217

RUNNING EXPENSES—FULL BEARING.

	£
Labour (Based on 1 unit at 6s., 93 units per ton cocoa in store)	3,300
Supervision	1,500
Transport Expenses	500
Building Maintenance	300
Stores/Supplies (Bags, insecticides, etc)	1,000
Tools	200
Administration	50
Insurance	100
	£6,950
Plus Amortisation	2,321
Interest at 4½ per cent.	522
Total Running Expenses	£9,793

RETURNS.

	£
Returns at £300 per ton in Plantation Store	15,000
Returns at £250 per ton in Plantation Store	12,250

NOTES ON BUDGET.

1st year	.... Clearing and planting 100 acres	50 labourers
2nd year	.... Clearing and planting 50 acres and maintenance of first year's planting	30 labourers
3rd year	.... Maintenance, completion of buildings, preparation of roads	30 labourers
4th year	.... Harvesting, maintenance	30 labourers
Full Bearing	Supervision allowance increased to £1,500 per year	40 labourers

To the end of the fourth year, interest charges added to capital.

Fifth year—Interest charges paid only.

Sixth year—From end of sixth year, amortisation and interest paid in ten equal instalments.

Full debt amortised fifteen years from commencement of scheme. Cocoa price quoted for value of produce in store on plantation.

ACKNOWLEDGMENTS.

The assistance given by the people listed below is gratefully acknowledged :—

1. Mr. N. Baker of the Commonwealth Department of Works, who prepared the plans of the cacao drier and fermentary.

2. Mr. L. Edwards of the Department of Forests, who prepared the diagrams on lining and shade arrangements.

3. Miss Chrisp and Miss Hill, for assistance with typing outside their normal duties.

4. Mr. C. H. Meen, for photograph of sun drier.

The following publications were consulted in the preparation of this article :—

Dun, G. S. (1954)—Notes on Capsids in New Guinea, *Papua and New Guinea Agric. Gaz.* 8, No. 4, pp. 7-11.

Dun, G. S. (1954)—Pests of Cacao in the Territory of Papua and New Guinea, p. 32 in Urquhart, D. H. and Dwyer, R. E. P. (1951)—*Prospects of Extending the Growing of Cacao in Papua and New Guinea.* Cadbury Bros. Ltd., Bournville.

Garrett, S. O. (1944)—Root Disease Fungi, pp. 177, Waltham, Mass., *Chronica Botanica Company.*

Green, E. C. D. (1938)—Cacao Cultivation and its Application to the Mandated Territory of New Guinea, *New Guinea Agric. Gaz.*, 4, No. 4, pp. 1-63.

REPORT ON MECHANIZATION OF AGRICULTURAL CROPS IN NEW GUINEA

K. EWART.

(Division of Agricultural Production, Department of Commerce and Agriculture, Melbourne, Victoria.)

Plantation Crops.

FOLLOWING on my visit to New Guinea in February-March, 1952, an interim report was prepared dealing mainly with mechanization of kenaf production. This final report covers field mechanization problems associated with plantation crops, viz. coconuts, rubber, cocoa, coffee and miscellaneous crops such as kapok and tung nuts. It has been prepared in three separately bound sections; this one deals exclusively with coconut plantations.

Coconut Plantations.

The outstanding field operations in copra production reviewed in terms of possible assistance from mechanization are :—

1. Maintaining clean plantations.
2. Pest control.
3. Harvesting the nuts—
   (i) gathering;
   (ii) extraction of meat; and
   (iii) transport.
4. Tractor use.

1. *Maintaining Clean Plantations.*—

There are important conditions which have to be taken into consideration in maintaining clean plantations. The terrain in the volcanic areas is often hilly and broken and coconuts and other obstacles lie in the ground cover. The primary objectives are presumably to maintain a ground cover which will protect the coconut palm roots, keep the soil temperature below the point of denitrification, check leaching and soil erosion, provide free nitrogen from a legume if possible and at the same time have a low, controlled growth on which the nuts can be readily seen and collected. This latter condition would be easy to achieve by cultivation or by mowing were it not for the other conditions desired. Cultivation cannot go beyond the use of the tandem disc harrow used in effect as a pasture harrow but plantation management would often consider this too severe on the vegetative ground cover needed. Mechanical mowing could be used under certain conditions but generally the terrain, hidden obstacles and speed of plant regrowth, make it impracticable. Where mowing can be done light engine-functioned, hand-directed, walking-type auto-scythes have manœuvrability and control which the tractor mower has not got. Anything would be better than the labour wasting sarif which is so much in evidence.

Rugged equipment which will crush down and cut vegetation without destroying it offers attractive possibilities and experimentation with what are variously known as brush, stalk or bracken cutters would be fully justified. There are two main types. One is based on a mechanically driven rotary cutting blade and it is considered that in the New Guinea environment there would be limitations to the effectiveness of this type. While more rugged than a mower it would have some of the limitations of the mower. It is the other type which has more scope. The basic principle of this second type is a self-revolving roller, skeleton drum or a series of wheels or discs on which metal flanges or cutting blades are welded. Obstacles such as coconuts, stones and light logs would not affect the operation of these implements and rough terrain would create no difficulties. If desirable, a light angle-blade or side rake could be fitted in front of the implement to push coconuts to one side. However, problems associated with avoiding damage to the nuts arise in the first place from failure to control the ground cover and would disappear once the control of vegetation (including refuse such as husks and palm fronds) became effective.

As there is no mechanical drive and the construction is simple and rugged, the maintenance of these implements is low, their operation simple and the initial capital cost is reasonable. There is a wide range of sub-types which should receive consideration for trial because their relative effectiveness varies widely with the environment and the work to be done.

Coconut tree nursery at "Matupi", Madang District.

Coconut plantation at Madang showing vine pest and Kunai grass.

Plantation at "Raenau", New Britain. Young cacao is seen growing underneath the canopy of twenty-feet-spaced coconut palms.

Coconut trees at "Raenau", showing broken, hilly country which forms large part of many plantations.

Sub-types suggested for consideration are :—

(*a*) *Wheel-type Bracken Crusher.*—

Cuthbertson Ltd., of Biggar, Scotland, has a design consisting of eight pairs of wheels in a heavy frame with " V " shaped cutters welded across each pair of wheels. The width of cut is eight feet, and the speed of working is approximately sixteen acres in an eight-hour day. The price of this unit delivered in Australia would be to the order of £380. Each pair of wheels has its own flexible axle so that if one pair of wheels rises over a ground obstruction, the other seven pairs retain contact with the ground.

(*b*) *Disc-type Cutter* (unrelated to a disc harrow).—

Cuthbertson of Scotland have what they call a " disc cultivator " consisting of two rows of four large discs set in tandem with transverse cutters around the periphery of each disc. Cuthbertson Ltd. describes the use of the disc cutter in the following terms :—

" This machine is being used for inter-row work in sisal fields in Africa, and for similar work in coconut groves. The action is that the vegetations between the crop rows should be chopped up and left on the ground, forming an insulating mat which prevents the ground temperatures from rising and retarding the growth of the crop. The machine is not intended to work at a considerable depth, as there is no necessity to bring up the parent soil ".

The discs have independent flexible axles enabling each one to float over an obstacle. The discs are mounted under a box frame and weight is added, up to two tons, if necessary, as ballast in the box to give penetration in dense vegetation. The action is more severe than that of the bracken cutter and would not be so suitable where a green manure crop was used. Approximate price delivered in Australia would be to the order of £590.

(*c*) *Skeleton Drum Stalk Cutter.*—

This is an American type designed for cutting weeds. Long cutting blades (eight to twelve) are bolted on to an open drum structure in the Caldwell model, which is typical. This sub-type is for relatively light work. The width of cut is variable depending on the number of drums employed. The cost is not available but the simplicity of this sub-type would insure that the cost was relatively low, say to the order of £250.

(*d*) *Roller Cutters.*—

This sub-type is basically a weighted roller, single or in gangs of two, three or four, with cutting flanges welded or bolted transversely across the cylindrical roller. The most advanced design is the American Marden used effectively in Texas and the South-West generally for clearing mesquite scrub. The principle is similar to the improvisation at Epo in the Mekeo area of New Guinea where flanges were welded on to an oil drum filled with concrete. There is also an Australian-made sub-type called the Robinson Wollard Bracken Fern Crusher manufactured by Hadens, Taree, New South Wales. This sub-type of cutter has worked effectively in bracken control in New South Wales and is well reported upon by the Agricultural Department for that State.

It is an important feature with all these sub-types that they have flexibility so that each unit in a gang floats over obstacles independently. This imposes a serious limitation on the roller used at Epo. The design and construction of independent axles is a difficult job; so is the design of suitable bearings and provision for lubrication.

There have been improvisations in New Guinea (see Dylup and elsewhere) such as a heavy channel iron drag, a heavy anchor chain drag and log rollers. There are disadvantages in the channel iron and log improvisations. They lost contact with the ground when passing over depressions and obstacles, and there is little scope for adjustment of weight or ground pressure. The channel iron and the log cannot float a section over an obstacle and has to ride high over its whole length, thus leaving vegetation untouched. Keeping plantations clean is so important that even minor improvements in the implement used are justified and the professionally designed and constructed implements are favoured. Nevertheless, credit is due to plantation managers who have improvised equipment.

It is considered that very considerable benefit could be obtained by field demonstrations to planters of sound examples of the agricultural engineering designs describ-

Sarif "sword" used for grass control by Native labour. It is made from hoop iron and is beaten out when the edge needs sharpening. The work with this universal New Guinea tool is slow and wasteful of labour.

Tandem disc harrows on "Raenau" used for keeping plantation clean.

Dehusking stick in use. The pointed stick is rammed tight into the ground.

Coconut halves shown with splitting knife alongside; jute sack filled with coconut halves ready for transport to the drying shed is in the background.

ed and that there would be justification in importing several machines for comparison. The following are suggested :—

(*a*) The Australian Robinson Wollard Bracken Crusher from Haden's, Taree, N.S.W., at an approximate price of £160;

(*b*) The Cuthbertson Bracken Crusher from Jas. C. Cuthbertson Ltd., Biggar, Scotland, at an approximate cost of £380, Australia.

(*c*) The English Hayter Bracken Fern Cutter (Rotary Cutting Blade principle) from Farm Fitters Aust. Ltd., Melbourne (Australian agent). Approximate cost £190.

The Cuthbertson disc cutter is also recommended if there is likely to be use for it in sisal plantations.

It is a recognized practice in some countries to associate cattle grazing with copra production and thus provide control over vegetation as a side line. This practice would not obviate the need for mechanical cutters as they would assist in bringing plantations under pasture and in renovating the heavy matted growth formed by many tropical pastures.

2. *Pest Control.*—

The control of such insect pests as sexava which involves spraying or dusting is difficult to accomplish by reason of the height of mature coconut palms; these may average some eighty feet.

Ground machines such as fog forming machines, high pressure volume sprayers, low volume sprayers and blast sprayers and dusters project or drift the specific for limited distances; 35 feet is usually considered a maximum distance in Australia for effective distribution of the pesticide. High pressure volume sprayers with, say, 600 pounds pressure and an exceptionally large nozzle opening could project a powerful stream of fluid to the under-side of the palm fronds. Such equipment would have to be specially made and would create difficult problems; the capital cost would be high; the unit would be exceedingly heavy; finally, an exceptionally wasteful amount of wash would be used and the costs on this account would be high. The top side of the fronds might not receive sufficient wash. The use of a high pressure volume sprayer with a tower mounted on a trailer could be given some consideration. However, in the U.S.A. where this type is sometimes used, the trees sprayed are not much over 30 feet high; there are practical limits to the height of the tower. Native labour could spray the palm tops by the laborious and slow process of climbing the trees; long hoses from high pressure volume sprayers or pressure knapsack sprayers could be used.

There is an American high-level blast-type machine which might be effective. It is called a Rotomist Duster and is made by the John Bean Division of the Food Machinery Corporation, San Jose, U.S.A. [Australian Agent—Food Machinery (Aust.) Ltd., Melbourne]. The manufacturers claim a maximum height for the direction of a pesticide of 100 feet. Liquid or dust can be used. The unit has a twenty-six horse power (rated) engine, weighs 2,200 pounds and is for mounting on a truck or utility. The approximate price is to the order of £1,500. The nozzle velocity is 165 miles per hour but the velocity loss is very rapid over a distance (roughly one-third for every six feet). The terrain would have to be sufficiently smooth to permit the passage of a motor truck. However, details and specifications (obtainable from the Melbourne agent) would be worth careful consideration.

The aeroplane would overcome the problems facing ground machines but may create difficulties of its own arising from the rugged terrain and flying conditions generally. Furthermore, the deposit on the under-side of the fronds may not be adequate. If the aeroplane were used, certain Australian experiences may be helpful. In brief, these are given below :—

(*a*) Where manœuvrability is important, light aircraft have many advantages;

(*b*) The Tiger Moth (D.H. 82) was the principal machine used. This was due to the low capital cost and availability from war disposal stocks. The Tiger Moth lacks capacity and versatility; its operational pay load allows for only some 30 gallons of wash. Higher pay loads are desirable, particularly when operating from a landing ground an appreciable distance from the area to be sprayed.

(*c*) The aircraft design should give the pilot a clear view of the target. This is vital with fixed-wing aircraft.

Copra—coconut halves after drying in a Ceylon air drying plant at "Siar", Madang.

Transport trailer used with a 22 h.p. max. on drawbar tractor. At "Raenau", New Britain, the whole nuts were transported from the field into the drying shed by this trailer.

A pile of whole nuts outside "Raenau" drying shed awaiting splitting and extraction of the meat.

A whole nut split with a special type of light axe at "Raenau".

(*d*) Liquid sprays have proved more effective than dusts. In particular, they are less affected by wind and easier to control.

(*e*) Spray bars with nozzles and alternatively venturi systems have been used effectively. The efficiency of the pump is highly important. A constant speed air-screw pump is desirable.

(*f*) Rotary winged aircraft have not been used in Australia for pest control; the capital expense and the operation costs were extremely high (overseas trends are towards the construction of more economical helicopter types).

(*g*) Equipment including the tank, pump, spray line, spray bar and nozzles can be made in Melbourne or Sydney to meet requirements. There are aeronautical engineering consultants available to prepare detailed specifications for the manufacturer.

3. *Harvesting the Nuts.*—

The following basic data was observed from the plantations examined in detail (Matupi and Siar at Madang; Raenau in the Gazelle Peninsula, New Britain). The average size of the plantations was 800 acres. There were two distinct methods of harvesting the nuts and curing the copra.

Method 1:—

(*a*) The nuts were gathered from the ground into small piles and dehusked by ramming on to a pointed stake or chisel-pointed iron bar fixed in the ground;

(*b*) The dehusked nuts were split in two with a heavy knife, bagged and transported by truck to the central drying plant; alternatively the dehusked nuts were transported whole to the drying plant and subsequently split in two;

(*c*) The half-nuts (shell and meat) were dried sufficiently to shrink the meat out of the shell. The drying process was continued with the meat to form copra halves.

(*d*) A Ceylon air drier was used.

Method 2:—

(*a*) The nuts were gathered into piles and transported by tractor trailer to the central drying plant;

(*b*) The nuts were then split (through husk, shell and meat) into halves with an axe;

(*c*) The meat was cut out in slices with a small knife and the meat slices were then placed in the drying trays;

(*d*) A modern kiln drier, using fan-inducted hot air from a furnace, was used. The hot air was directed underneath perforated trays holding the copra slices.

The second method provided a by-product in the form of the coconut fibre from the husk as raw material for sale to a factory processing matting, etc.

The harvesting was essentially a manual process involving some 300 Native boys who have to be housed and fed.

The time factors in the above operations are variable but observations of Method 1 indicated the following:—

Gathering the nuts, 60 per cent.;

Dehusking, 25 per cent.;

Splitting and bagging, 15 per cent.

The average boy on "Matupi" gathered, dehusked, split and bagged 300 nuts (four bags). Loading and transport of the bagged half-nuts did not take up a major amount of time. Under Method 2, there was a saving in dehusking but loading and transport took more time and meat extraction was an added labour.

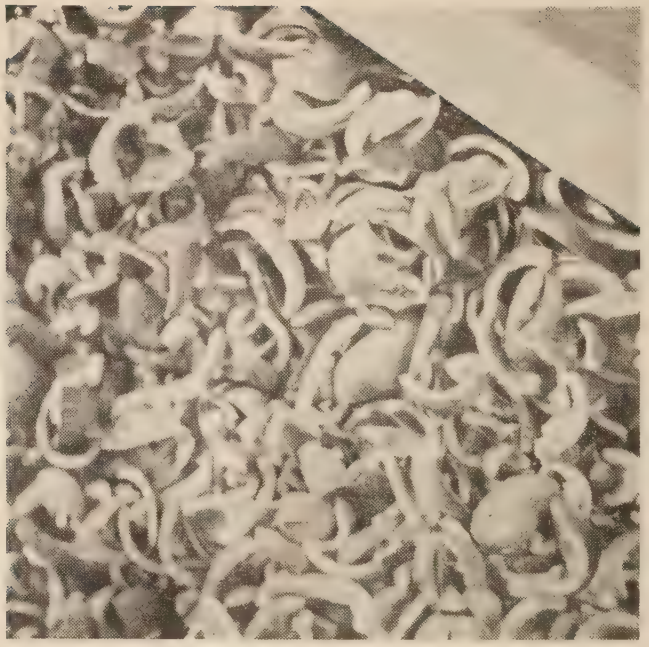
Mechanization possibilities are reviewed in terms of three processes; gathering the nuts, dehusking and splitting, and finally transport.

(*a*) *Gathering Nuts.*—

There is evidence that this takes up the greatest amount of time. The chief difficulty is to find the nuts hidden in the vegetation and debris. If the mechanization methods suggested for keeping the plantations clean were carried out efficiently, the nuts would be easy to see and pick up manually. It would not be difficult to devise an attachment for mounting in front or behind a tractor to sweep up the nuts. It is doubted, however, whether the cost would be justified; more than one tractor would be required. A first essential is clean ground with no more vegetation than is provided by a well-controlled legume of prostrate growth habit. Palm frond debris should not be allowed to accumulate and it is likely that a suitable scrub- or fern-crushing machine as described above will assist in disintegrating such debris. Machines with weight and blades properly adjusted

Slicing out the coconut meat with a knife. A series of cuts are made and the meat then loosens and lifts out. The halves with the fibre intact can be sold as raw material for coconut matting.

The dry shed (copra curing plant) at "Raenau".



Coconut slices in the drying tray of the kiln drier at "Raenau".

The "Raenau" Plantation's modern drying kiln processed 56 tons of copra a month. Hot air from a furnace is inducted by a fan down an air chamber underneath perforated drying trays.

should not disturb the legume growth beyond the necessary control required.

(*b*) *Dehusking and Splitting.*—

There have been experiments in dehusking and splitting mechanically but there is no available evidence so far of a successful machine. In any case, as indicated above, the time taken up in dehusking and splitting is less than half that of gathering the nuts.

(*c*) *Transport.*—

It is considered that this can be done most efficiently by the use of a light, mobile tractor and trailer. The tractor can negotiate wet, boggy conditions better than a truck and the floor of the trailer is lower for loading. It is appreciated that there are general uses for a truck for which it has advantages, particularly for transport of copra and supplies for relatively long distances. There are many uses for a tractor on a plantation as will be discussed below. The tractor trailer's work will be particularly effective in moving between the palms in rough or wet terrain. A likely type is a two-wheeled, three-ton capacity trailer with a trap about ten by six feet, and high sides. A tipping tray may have worthwhile advantages over a fixed one. The two-wheeled types give added traction by bearing their weight on the driving wheels of the tractor. They are highly manœuvrable and easy to couple.

(4) *Tractor Power.*—

The small extent which coconut plantation management drew on mechanical equipment and tractor power was surprising. No doubt this has an historical background involving cheap and plentiful labour supply. (It is no longer cheap, nor plentiful.) There are also present difficulties arising from the near-absence of local commercial servicing facilities and the cost of transporting a mechanic by air from a main centre (or the delay by water transport). In a changing scene, some plantation management has not yet sufficient mechanical knowledge to be independent of outside help. This is certainly a prerequisite to the use of tractors and field machines on plantations.

There is much scope for tractor use and the capital cost is small in proportion to the total capital employed in a plantation. Apart from obvious uses in maintaining clean plantations and providing transport, tractors can be used for many auxiliary purposes by using the belt drive or power take-off or by using pneumatic power from a compressor driven by the tractor. Wheel tractors of 20 to 25 horse-power maximum on the drawbar, with provision for direct coupling of equipment, would be suitable for transport and general work. Small crawlers are effective for clearing light scrub and debris and where the terrain is particularly difficult.

It would be feasible for a plantation to employ two tractors; a light or light-medium crawler of 25 to 35 horse-power maximum on drawbar and a light-wheel tractor as described above. With adequate tractor power available, it would be practicable to grow rice, sweet potatoes, peanuts and other crops to provide a balanced diet of plantation-grown rations for the Natives employed.

BRUCELLOSIS OF CATTLE

This is a scourge of the first importance, rendering thousands of cows sterile, lowering milk yields, upsetting breeding programmes, and disrupting genetic lines. It is also known as Contagious Abortion and Bang's Disease. The actual cause is a microscopic germ known technically as *Brucella abortus*. Contact with infection is the main factor which leads to the spread of the disease.

Cattle are susceptible after they have once reached sexual maturity. Young animals up to about six months of age frequently have a resistance to the disease, particularly when they are the progeny of infected cows. Horses and various other animals (including man to a small degree) are sometimes affected.

The infection is contracted mainly by eating the germ with the pasture. Infective discharges pass from the genital tract, and the dung and urine may carry the germ, so that the infection is readily picked up by grazing animals. Occasionally a bull may be affected in the testicles, in which case he may possibly infect cows at the time of service. It is possible that at times he may transmit the disease mechanically from an affected cow to the next uninfected cow which he serves. Infection may be introduced on to the farm by untested cattle which are carriers of the disease. Flies may transmit the disease. They may alight on the after-birth from an infected cow, and then on the eye of another beast. Infectious material placed in the eye will readily cause infection.

The germ may live for many months in shady, protected positions.

Cows which have been infected may abort once, but seldom abort again, as they develop tolerance to the disease. Though they do not abort, they remain carriers of the disease. Such carriers will avoid infectious dung, urine and discharges, and so act as disseminators of the condition.

Generally speaking, the animal shows no symptoms such as temperature, or obvious illness, but after infection the calf may be aborted at varying stages of pregnancy, often about the fourth or fifth month. The calf is frequently dead, even if old enough to be born alive. The aborted foetal membranes (after-birth) show patches of dead tissue on them. There may be a continuous discharge for some time, due to inflammation of the uterus, the neck of the uterus, or the vagina. At subsequent pregnancy, the cow usually retains the calf until full time, but the infection still remains, and in such cases the incidence of dead calves in the herd is markedly increased. Further, after calving has occurred, it is common for trouble to occur with " the cleanings ".

The cow retains the after-birth and, as a result of secondary infection, inflammation of the uterus and other parts of the genital tract is very common, resulting in sterility. Infection may travel up the fallopian tubes, leading to changes in the ovaries, such as cystic conditions, which effectively prevent further breeding.

It has been demonstrated that in the non-pregnant period, the germ may become located in the udder of an infected animal, and the presence of this udder infection appears to decrease the milk production somewhat. The economic loss due to this decreased production is hard to assess, but may be of significance.

The most reliable method of diagnosis is to collect blood samples, and forward the serum to a veterinary laboratory for submission to the agglutination test. This test, like other biological tests, is not one hundred per cent. accurate, and this is particularly so in the case of pregnant cows. Cases have been reported where carrier cows gave a negative reaction after calving or aborting. Further, one test must not be relied upon, but at least two negative tests must be obtained before a cow is presumed to be free from infection. Once a herd is free, no cow should be introduced unless it has passed two clean tests, and further, if pregnant, it is desirable to retain such an animal in isolation until a fortnight after calving, when a further test should be

carried out to ensure that she is free from the disease.

From cows that have aborted specimens may be forwarded to the veterinary laboratory for examination as follows :—

Where the foetus can be delivered in a fresh condition to the laboratory, this is the best specimen. If the foetus would be too decomposed on arrival, it should be autopsied and the following specimens forwarded—

Pipettes of foetal liver ;

pipettes of foetal stomach content ;

3 air-dried smears of foetal stomach ;

2 air-dried smears of foetal cotyledons ;

pieces of liver and cotyledons in formalin.

Also send from the dam—

blood serum ;

milk sample (for ring test) ;

vaginal mucus in sterile bottle ;

3 air-dried smears of vaginal mucus.

From milking herds send also—

bulk milk sample.

Advice should also be forwarded as follows :—

age of foetus if date of service known ;

size of foetus ;

whether foetus carries hair ;

temperature of dam, taken as soon after abortion as possible ;

whether dam has been driven, transported or otherwise physically exerted prior to abortion ;

whether foetus shows any signs of goitre (if so, also send appropriate specimens).

The only effective means of control is to institute testing. When this is done, reacting animals should be removed forthwith. They may be sold for beef, or placed in a separate herd, which is kept under isolation. From such a herd of infected cows, healthy calves may be reared, if they are removed soon after birth and kept in uncontaminated premises. It will be necessary, in the transfer of such calves to clean premises, to shift them first into an intermediate resting property. If this is not done, they may act as mechanical carriers of the germ to older (and susceptible) animals on the clean property. Once a herd is clean, every care must be taken to prevent the introduction of animals not free from the disease.

The disease may be present in horses, and to a less extent in other animals, though rarely in sheep, and where eradication is difficult, blood testing of horses on the farm is usually carried out. The commonest symptom in the horse is fistulous withers.

Unless some care is taken, many cases of sterility may follow abortion infection.

Thus when the disease is in a herd, every care should be taken to limit its harmful effects, so far as possible. Aborting cows should be isolated, the foetus and membranes burned, and the cow syringed out with dilute antiseptic, such as one per cent. dettol, or 0.2 per cent. zinc sulphate, until all discharges cease. No cow that is showing a vaginal discharge should be put to the bull.

When there is any disease of the genital organs in various cows of the herd, it is of particular importance to keep the bull in a separate paddock, otherwise he will serve a "discharging" cow and then a "clean" one, and may in this way spread the disease from cow to cow.

Vaccination of calves is practised in some countries. This procedure is not completely safe, however, and will not be recommended in this Territory until we have further information on the incidence of Brucellosis here.

Calves should be inoculated between the age of four and eight months, preferably five months. After inoculation the calf becomes a positive reactor to the agglutination test for brucellosis but they become negative again by the time they reach breeding age. Most of them remain immune to further infection.

Before vaccination is carried out it is essential that a veterinary surgeon take a blood test of the herd to determine whether the condition is actually present.

Treatment of affected animals is likewise not recommended.

COVER CROPS AND GREEN MANURES

The subject of this talk is a most important one for all phases of agricultural production in the Territory. Ordinarily speaking, cover cropping and green manuring fall into the category of techniques for the conservation, restoration and improvement of soils by the use of selected plants and can be classed with major measures of this type such as reafforestation. These measures cannot be ignored in areas such as this Territory, where soils are subjected to the action of radical climatic factors in the form of high rainfalls and high temperatures. Also the cost structure of many Territory industries is such that the possibility of profitably using fertilizers is extremely doubtful and, therefore, all available natural methods of improving the soil must be used.

The two techniques have essentially different aims, the purpose of cover cropping being to provide a protective living cover on the soil while the aim of green manuring is to grow a crop which will provide a suitable bulk of green matter to turn into the soil for rotting down and thus increasing its humus content. Both, however, achieve the same sort of result in the long run; a well established cover crop is continually dropping organic matter on to the soil surface, which rots down and adds to the humus content of the soil, while the physical effect of increasing the humus content of top-soil with green manure is also protective against rain and other weather elements. The principal point of difference is that green manuring actually involves intensive cultivation to force the plant material into the top-soil, and for this reason it is less desirable than cover cropping under high rainfall conditions.

The group of plants which have achieved prime importance for use in this special field of agriculture are those known as "legumes". Originally, attention was concentrated on them because it was known that certain species of legumes, particularly the clovers, pulses and similar plants have bacterial nodules on their roots which could fix nitrogen in the atmosphere and convert it into a form suitable for plant food.

It was argued that this was the main reason why these crops were so valuable for soil restoration. However, it has now been found that this process does not take place with many legumes, including some of the more important ones used in the tropics and other reasons have been sought to explain their value. It is certain that the cultivated plants of the legume group very readily produce a bulk of soft green leafy material suitable for incorporation in the soil and that in many cases they will do this on soil which is exhausted or eroded to a point where general cropping is uneconomic. It is thought to be important that even though most of the legumes in use are relatively soft, creeping plants or small shrubs they, nevertheless, have deep strong tap-roots capable of bringing up mineral plant foods from the lower level of soils.

Discussing some of the more important types of legumes which are useful for this purpose in the Territory.

Firstly, the Creepers.—

Generally speaking these are most important in the field of cover cropping, particularly in coconut plantations. They tend to develop strong fibrous creeping stems and although they are wonderfully leafy and form a fine mat in plantations of permanent crops, they are less desirable for use in annual crop cultivation as they tend to tangle up implements. Also if any loose seed is left in the cropping area they grow strongly towards the light and will pull down annual crops such as rice, kenaf and sorghum. Some of the best known cover crops for coconut plantations are found in this group. They include the *Pueraria* or *Kudzus*, with their strong-growing, hairy vines, pretty pinkish-purple flowers and prominent hairy pods; the *Centrosemas* which are smoother leafed, with delicate blue flowers and minute hairy pods and the thicker-leaf *Calapogoniums* which do well in sandy soils near the sea. *Vigna marina*, a yellow-flowering legume occurs naturally

in this Territory in salty beach sand near the sea and often gives cover on the beach area of plantations where other legumes will not grow. It is cultivated for this purpose in some countries.

One of the most effective of the leguminous covers is small creeping Mimosa, there being few plants which give a better cover or are more easily worked into the soil. However, it is disliked because of its spininess, giving detrimental effects on livestock and tending to cause skin complaints with Native workers. Advice has recently been received of a spineless variety of this plant and this is being investigated. If such a variety exists it would really be a boon to the planting industry. It is important to note that two of the well-known covers, *Peuraria* and *Centrosema* are also valuable grazing plants in the tropics and it is thought that cattle raising and coconut production can be very profitably combined using these covers.

Secondly, the erect group of Legumes.—

Here we have a very wide variety of types from which to choose and the most important of the green manures are found in this category. Some of the most effective green manures belong to the annual pulses, such as the Cowpea or Poona pea and the Mungo bean or Green gram. These fast-growing annuals rapidly provide a dense mat of soft green matter which is very easily digested when worked into the soil. There are also a wide variety of shrubby legumes suitable for such purposes, which include such well-known members as the *Crotalarias*, Pigeon pea, and *Tephrosia*. This group often serves a dual purpose in providing early shade for crops such as cocoa and coffee, at the same time protecting the soil and when slashed giving a good mulch.

It should be fully appreciated that green manure crops, while they are growing, also serve as a cover for the soil, and indeed the cover cropping principal needs to be introduced into annual crop production in this Territory. Fallow land should never be cultivated here to the extent that it is kept bare as is often done in temperate climates. Under our conditions such exposed soils will not stand up to the effect of rainfall and sunlight and will lose their humus content and have valuable minerals leached out of the soil. A well-managed cover crop is a far better form of fallow than any other for this Territory. One misconception needs correcting here, and that is the prevalent idea that peanuts are valuable from this point of view. It is pointed out that peanuts when they are cropped remove large quantities of mineral nutrients from soils and although the vines should be returned to the soil the gain from this is far less than the general loss of plant foods. Peanuts should always be brought in at the end of a rotation, if possible.

MISCELLANEOUS BOTANICAL NOTES

A Foetid Weed from Rabaul

J. S. Womersley, B.Sc.*

FOR some years, probably at least from some time during the 1939-1945 War, a foetid-smelling weed has been found within the town of Rabaul on New Britain. In 1953, through the courtesy of the local District Agricultural Officer, flowering material of this plant was obtained. This has now been identified as *Paederia foetida* Linn, family Rubiaceae.

This plant has also been referred to under the name *Paederia tomentosa* Bl. which was reduced to a synonym of *P. feotida* Linn by Merrill in his *Enumeration of Philippines Plants*.

Paederia foetida is widespread from India to Japan, China, Malay Peninsula and the Philippines. It is probably an introduction to New Guinea, although a specimen was collected in the Kani Mountains by Schlechter in 1901 at an altitude of 2,200 feet. This record may refer to a plant other than the present species.

Herbarium material of the species is illustrated. The following description is based largely on dried herbarium material :—

Paederia foetida Linn.—

P. tomentosa Bl.

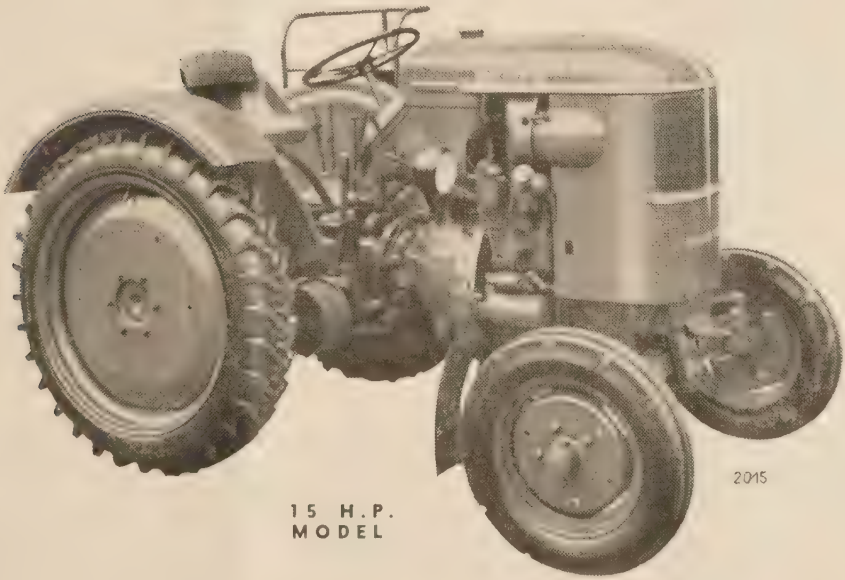
Twining shrub or scandent herb; leaves opposite, stipulate, petiolate, lamina thin, papery; stem, twining. Inflorescence axillary and terminal; flowers in scorpioid corymbs; calyx small, green, finely five-lobed; corolla tubular, lobes scarcely expanded; finely ferrugineously pubescent externally; internally glabrous, pale violet with dark violet spots. Ripe fruits not seen. All parts of the plant possess an unpleasant, foetid odour, especially towards evening. The plants apparently spread from the fine seed.

It is likely that this plant could be controlled or eradicated by use of a hormone spray or simple cultivation. It is a weed of waste land only.

* Forest Botanist, Department of Forests, Papua and New Guinea Administration.

for service

MOST DEPENDABLE
BECAUSE THEY'RE AIR-COOLED !



15 H.P.
MODEL

DEUTZ
DIESEL TRACTORS

Throughout the Tropics—in the Philippines, Indonesia, Africa, Central and South America, DEUTZ world famous air-cooled Diesel Tractors have proved themselves under the toughest conditions—over 35,000 in use to-day ! Air-cooling means your tractor is far more dependable—the entire water-cooling system is eliminated. No radiator, water pump, gaskets, water jackets, etc., to give trouble. Air-cooling is superior because it's **direct** cooling—efficient and guaranteed up to 140° F. ambient Temperature.

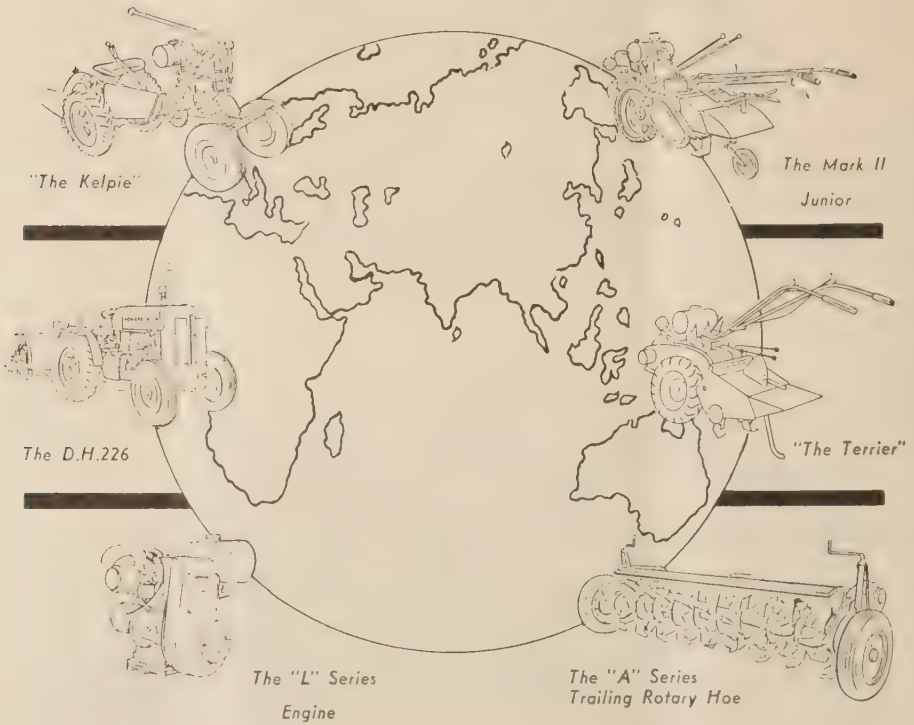
You can't buy better than DEUTZ ! Other models, too ! 30 H.P., 45 H.P. and 60 H.P., both wheel and crawler.

Full range Spare Parts in Stock.

COLYER WATSON (NEW GUINEA) LTD.

RABAUL - MADANG - KAVIENG - LAE - GOROKA

"AN AUSTRALIAN IDEA"



Just over thirty years ago, the first Howard Rotary Hoe was built. Since then, Howard Auto-Cultivators Ltd. has played a most important part in this country's agricultural progress. At the same time, this company has successfully introduced the principles of rotary tillage in countries all over the world. In South America South Africa, the Pacific, the Near East and many other world markets, you will find the Rotary Hoes and Tractors of Howard Auto at work. More recently, Howard Auto Engine Units, designed to offer top performance with low initial cost, have also found a ready sale. Interested people are invited to send inquiries covering any particular country or state direct to HOWARD AUTO-CULTIVATORS LTD., Northmead, N.S.W.

World's first rotary hoe! At left is an actual photograph of the original Howard Rotary Hoe, produced in 1923 in a small wheelwright's shop in Moss Vale, N.S.W. From this pioneer model has sprung today's huge Howard Auto organisation.

HOWARD Auto-Cultivators Ltd.

Windsor Road, Northmead, N.S.W.

Printed and published by William Samuel Nicholas, Government Printer, Port Moresby.—6942/6.55.